MODERNIZING HANDLING SYSTEMS FOR FLORIDA CITRUS FROM PICKING TO PACKING LINE

Marketing Research Report No. 914

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with the
Florida Agricultural Experiment Stations

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PREFACE

Work covered by Marketing Research Report 529, "Handling Florida Oranges in Pallet Boxes," was continued and is reported here. This study was conducted as part of a cooperative research program by the Agricultural Research Service, U.S. Department of Agriculture, and the Florida Agricultural Experiment Stations, Institute of Food and Agricultural Sciences of the University of Florida. It was under the general supervision of the following persons: Joseph F. Herrick, Jr., investigations leader, Handling and Facilities Research Branch, Transportation and Facilities Research Division, and Jordan Levin, investigations leader, Harvesting and Farm Processing Research Branch, Agricultural Engineering Research Division, U.S. Department of Agriculture; and K. R. Tefertiller, chairman, Department of Agricultural Economics, D. T. Kinard, Department of Agricultural Engineering, and H. J. Reitz, head, Citrus Experiment Station, University of Florida.

As production of citrus fruit expands and labor rates increase, there will naturally be greater concern regarding cost and other aspects of modernizing various handling systems.

Appreciation is expressed especially to Adams Packing Association, Inc., Brooksville Citrus Growers Association, Golden Gem Growers, Inc., Haines City Citrus Growers Association, Lake Region Packing Association, Lake Wales Citrus Growers Association, Inc., and Spada Fruit Sales Agency, Inc., for making their operations available for this research. To a lesser extent, many other firms also made their operations available, and since it is not practical to acknowledge them individually, appreciation is expressed to the Florida Fresh Citrus Shippers Association for the cooperation of the industry as a whole.

Information furnished by American Machinery Corporation, Petersen Industrial Machines, and Vernon E. Ramsey, Inc., is gratefully acknowledged.

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By Earl K. Bowman, *industrial engineer, Transportation and Facilities Research Division, Agricultural Research Service;* A. H. Spurlock, *agricultural economist, Agricultural Economics Department, University of Florida;* Scott Hedden, *agricultural engineer, Agricultural Engineering Research Division, Agricultural Research Service;* and William Grierson, *horticulturist, Citrus Experiment Station, Florida Agricultural Experiment Stations*

SUMMARY

The purpose of this study is to provide costs, labor and equipment requirements, and various engineering-economic data for use in planning improved systems for handling citrus from picking to packing line. Four systems are described and compared.

The full-bulk system offers annual savings of $46,000 over the field-box system for a volume of 500,000 field boxes. A major construction program is required to change to this system from existing field-box facilities.

Possible savings with the pallet-box system over the field-box system, based on data from full-scale commercial operations, are shown to be greater than reported previously from experimental operations. Annual savings up to $49,000, based on 1967 costs, are indicated for the same volume as the full-bulk system. Usually the easiest, although not necessarily the best, way to modernize a field-box system will be conversion to a pallet-box system using existing facilities to the greatest extent possible.

The modified-bulk system shows essentially the same savings potential as the pallet-box system. To change to this system from a field-box system entails less extensive facility construction than for the full-bulk system since the bins are not required; however, the side-sloping driveway and unloading stations are the same for the full-bulk and modified-bulk systems.

Savings shown for these last two systems do not include pregrading and presizing, which can be conveniently incorporated in each system. Both these systems can use the same grove and transport equipment for moving fruit to either the packinghouse or the processing plant.

Boom-type lift equipment has been chosen instead of the tractor forklift for pallet-box systems by a large proportion of fresh-citrus firms. It requires several boom-lift goat trucks equivalent to the number of tractor forklifts and flatbed goat trucks combined for comparable capacity. The number of operators and the cost per box are essentially the same for pallet-box systems whether boom-type lift or tractor forklift equipment is used. The choice is, therefore, dependent on a combination of factors, some of which may be difficult to define clearly. Apparently multiuse adaptability—handling fresh fruit and fruit for processing with the same equipment—and greater hauling capacity for a lift-equipped goat truck than a tractor forklift unit have been important considerations in choosing equipment.

Stresses induced in a box differ when gripped and lifted by the top instead of by the bottom with forklift equipment. Whether this is significant in box maintenance and useful life is not known, but it is evident that the sides must be securely attached to a sufficiently rigid pallet base for top lifting. In addition, each firm should consider its own particular conditions, such as possible differences in fruit injury or requirements of grove terrain and soil as related to the types of lift equipment and containers.

The slatted, metal-bound, wood pallet boxes, mass-produced by box manufacturers and used predominantly in Florida fresh-citrus operations, have performed well relative to their cost. Well-

made plywood pallet boxes have recently become available in the Florida citrus area. Maintenance costs and useful life for the two types of box construction can be compared as sufficient experience is gained.

The latest type of grove-to-packinghouse transport in the pallet-box system in Florida is the straddle trailer. Data on this equipment indicate a potential savings over flatbed semitrailers when the one-way haul is less than 11 miles. At 5 miles the savings would be about 2.8 cents per field-box equivalent. Scheduling must be accurate for each unit in use to eliminate delay such as waiting for fruit at a pickup point.

INTRODUCTION

For many years wooden field boxes were used exclusively by the Florida citrus industry to handle citrus fruit from the picker to the packing line. The field-box system has been essentially uniform since 1875 (*4*).[1]

However, in recent years changes have taken place and other systems have been adopted either partially or entirely. The effects of the field-box system are still far reaching. The dimensions and volumetric capacity of the field box have long been included in Florida citrus fruit laws 601.86. Each of the two compartments in a field box, formed by a partition prescribed in the statutes, is specified as having a volume of 2,400 cubic inches, or a total volume of 4,800 cubic inches for one field box. This legal volume of 4,800 cubic inches, or approximately 2.23 bushels, is measured to the top of the side slats, not level with the top of the handles.

Development of equipment and methods that work easily and effectively with the field box was encouraged for many years by the stability in size and configuration of the box resulting from the statutes. Grove trucks, over-the-road transport equipment, handling equipment at the packinghouse, structure and arrangement of the packinghouse receiving facilities, and degreening-room design and layout all have been greatly influenced by this container. Sheds for storing the empty boxes have been constructed at most packinghouses. Within the packinghouse, conveyors suitable for moving stacked field boxes to the dumping point, machines for automatically dumping the fruit from the boxes onto packing-line entry conveyors, and conveyors for taking empty boxes away and delivering them to a storage shed or outside loading point all have been especially designed and arranged for the field box (*9*).

The field box has served the industry well. However, workers no longer can be expected to handle a 105- to 110-pound filled container. Expecting them to do so, particularly many times daily, not only entails excessive manual labor incompatible with modern concepts but also makes the entire harvesting and packing operation dependent on the stability of a few strong-backed individuals. Furthermore, extensive experience has shown that the useful life of a field box is relatively short and the maintenance cost is relatively high.

Research was conducted on a bulk-handling system suitable for fresh fruit in a cooperative effort of the Citrus Experiment Station of the Florida Agricultural Experiment Stations and the U.S. Department of Agriculture from 1948 to 1954. The research resulted in the development of a system for bulk handling oranges and grapefruit for the fresh-fruit market from the picker to the packing line (*11*). This system was similar to that already accepted for bulk handling of fruit for processing. Although fruit for fresh use was usually handled differently in the grove to reduce possible injury, it was transported from the grove to the packinghouse in bulk in large semitrailers. Normally fruit for fresh use was not loaded to as great a depth in the semitrailer, however, as fruit for the processing plant. The unloading operation was also different. The entire operation was made possible by developing fabric-baffled bulk bins for fresh fruit.

Frozen orange juice concentrate, which was developed to a marketable stage about 1947, found such acceptance with consumers that the quantity of oranges marketed in processed form increased substantially year after year. Meanwhile the quantity of Florida oranges for fresh consumption remained relatively constant for about 10

[1] Italic numbers in parentheses refer to Literature Cited, p. 43.

years and then declined. Today 85 to 90 percent of the oranges are processed. On the other hand, about 40 percent of the grapefruit in Florida are marketed "fresh." Prior to the development of frozen orange juice concentrate, the processing industry used fruit diverted from the fresh-fruit packing operations. Total annual production of oranges in Florida has increased from 58.5 to 144.5 million boxes and for grapefruit from 24.2 to 43.6 million boxes from 1949–50 to 1966–67 (*1*).

The bulk system for handling fresh fruit was adopted by some fresh-citrus firms and made possible a substantial saving in labor. However, this system required new, specialized equipment in the grove and a special facility at the packinghouse, including conveyors and vertical elevators for receiving the fruit in bulk and provisions for degreening in cloth-baffled bins, holding an equivalent of 100 to 250 boxes of fruit each. By 1958 the adoption of this system, to be referred to as the full-bulk system, was still rather limited, principally because of an almost universal reluctance to abandon the custom of keeping lots separate from different groves, growers, or contracts.

To provide an alternate approach to modernization, cooperative research by the Florida Citrus Experiment Station and the U.S. Department of Agriculture was renewed, this time on developing a pallet-box system. The effective date of the memorandum of agreement for this research was July 1, 1959. After several seasons of work, which included operation of an experimental pallet-box system in collaboration with a commercial citrus firm, findings were presented in an interim report (*4*). It indicated potential worthwhile savings with a pallet-box system as compared to the field-box system. The boxes that were especially procured for this research, the equipment for handling them, and the experimental operation have been described in this earlier publication (*4*).

During this time the purpose of the research was (1) to obtain information on the practicability of pallet boxes for handling fresh citrus from the picker to the packing line and (2) to develop and present comparative data on fruit injury and costs for the pallet-box and field-box systems.

In 1961 citrus firms [2] began to make full-scale use of the pallet-box system for handling citrus for fresh use from the picker to the packing line, and its practicability was confirmed in a relatively short time. Each succeeding year additional firms have accepted pallet boxes for fresh-fruit handling. However, their use has varied. For example, boom-type equipment for lifting and handling the pallet boxes at the grove has been introduced. It is another way of performing the operations for which a tractor forklift was used both in the research period and by the commercial firm that installed the first full-scale pallet-box system.

More recently other firms have been using a combination of the bulk and pallet-box systems. Bulk methods are used in the grove and in transport to the packinghouse, where during the degreening season fruit is placed in pallet boxes. Succeeding steps are then essentially the same as for a regular pallet-box system.

As the newer pallet boxes became available, box suppliers arranged to lease them. This permits a user to obtain boxes without capital outlay and to use them without having repairs made by his own organization. The relationship between lease cost at a given time and cost of purchasing and maintaining boxes must be considered for each situation.

PURPOSE AND METHOD OF STUDY

With the advent of commercial-scale pallet-box operations, labor and equipment values and other data from the experimental period were reexamined free from the characteristic effects of unskilled operators of new equipment. Also data were collected on additional kinds and combinations of equipment not previously available for study for use in planning improved systems for handling citrus from picking to packing line.

Degreening rooms have been designed specifically for pallet-box use. Mechanical unstacking and stacking units for pallet boxes facilitate dumping and reduce the demands on the forklift operation.

Comparative costs and supplemental information are provided in this report for the field-box, the full-bulk, the pallet-box, and the modified-bulk systems currently in use.

[2] Include corporations, cooperatives, and grower-packers.

Productive-time requirements for labor and equipment were developed from time-study data using recognized techniques. For the field-box system, data from earlier work [3] (*13*) were used extensively and compared with time-study data obtained more recently on the same operations. The data used in connection with the other systems came from work done since the interim report (*4*) was published.

Injury tests were not conducted on oranges during later work mainly concerned with commercial operations. Commercial conditions present many difficulties relative to the necessary sampling and special arrangements needed for valid comparisons. Variation between firms may exceed variation due to systems. However, all systems are used by established firms that market fruit through normal channels. For so-called "tender fruit," the injury effect was observed partly near the end of the earlier period of work on pallet-box handling and partly during the 1963–64 season.

Partitions were made for a few pallet boxes originally designed for oranges and grapefruit to divide them into four equal compartments of full depth for testing pallet-box handling treatment on tangerines.

Fruit was handled from the picker to the packinghouse, as in a commercial operation, and placed in separate compartments at depths of 18, 22, and 26 inches. Field boxes of tangerines, handled as part of each load, were included in the tests to provide the reference or control data.

Pallet boxes without partitions were also tested. They were filled with tangerines to a depth of approximately 26 inches, as is normally done for oranges and grapefruit. The filled pallet boxes stacked two high and field boxes of tangerines stacked four high on a truck were hauled approximately 10 miles on rough country roads and 10 miles on paved roads. Standard decay tests were conducted by the Florida Citrus Experiment Station on samples of fruit from these tests.

Approximate costs were developed to compare the four systems of fresh-fruit handling in current use. These costs covered activities from tree to packing line, including picking, loading, hauling, unloading, presizing where feasible, degreening, and dumping.

Labor and machine input values, determined by time-study or work-sampling techniques, were utilized. In some instances these data were taken from earlier research (*4*, *11*, *12*). The equipment required for each system at three weekly output rates was determined, and the annual fixed cost was calculated independent of the hours of use per year. Fixed costs included depreciation, licenses, insurance, taxes, and interest on equipment using 1967 values. For each weekly output rate, per-box costs for equipment were computed at several annual volumes.

Direct costs included those items directly associated with operating expenses, such as fuel and lubricants, electric power, maintenance, and repairs.

The labor and equipment requirements were used with 1967 wages and prices to determine operating costs.

Annual fixed costs for equipment and direct operating costs for labor and equipment were calculated for weekly output rates of 8,000, 16,000, and 24,000 field-box equivalents and applied to annual volumes of 100,000 to 700,000 boxes to obtain a total cost per box.

FIELD-BOX SYSTEM

Description

The field-box system is the benchmark with which costs for the other systems are compared. A flow chart of this system is shown in figure 1, and the activities in the chart are summarized in table 22 (appendix).

Out of season the empty field boxes are stored in a shed constructed for the purpose. In season they are moved to the grove, usually on flatbed semitrailers. Where investment is limited or travel distance is short, the boxes may be transported on regular trucks. The semitrailer loaded with empty boxes is moved to a transfer point near the grove,

[3] THOR, E. THE APPLICATION OF ECONOMIC-ENGINEERING RESEARCH TECHNIQUES IN PLANNING OF FRUIT AND VEGETABLE PACKING PLANTS WITH SPECIAL REFERENCE TO FLORIDA CITRUS 1956. [Unpublished doctor's dissertation. Copy on file Dept. of Agr. Econ., Univ. of Calif., Berkeley.]

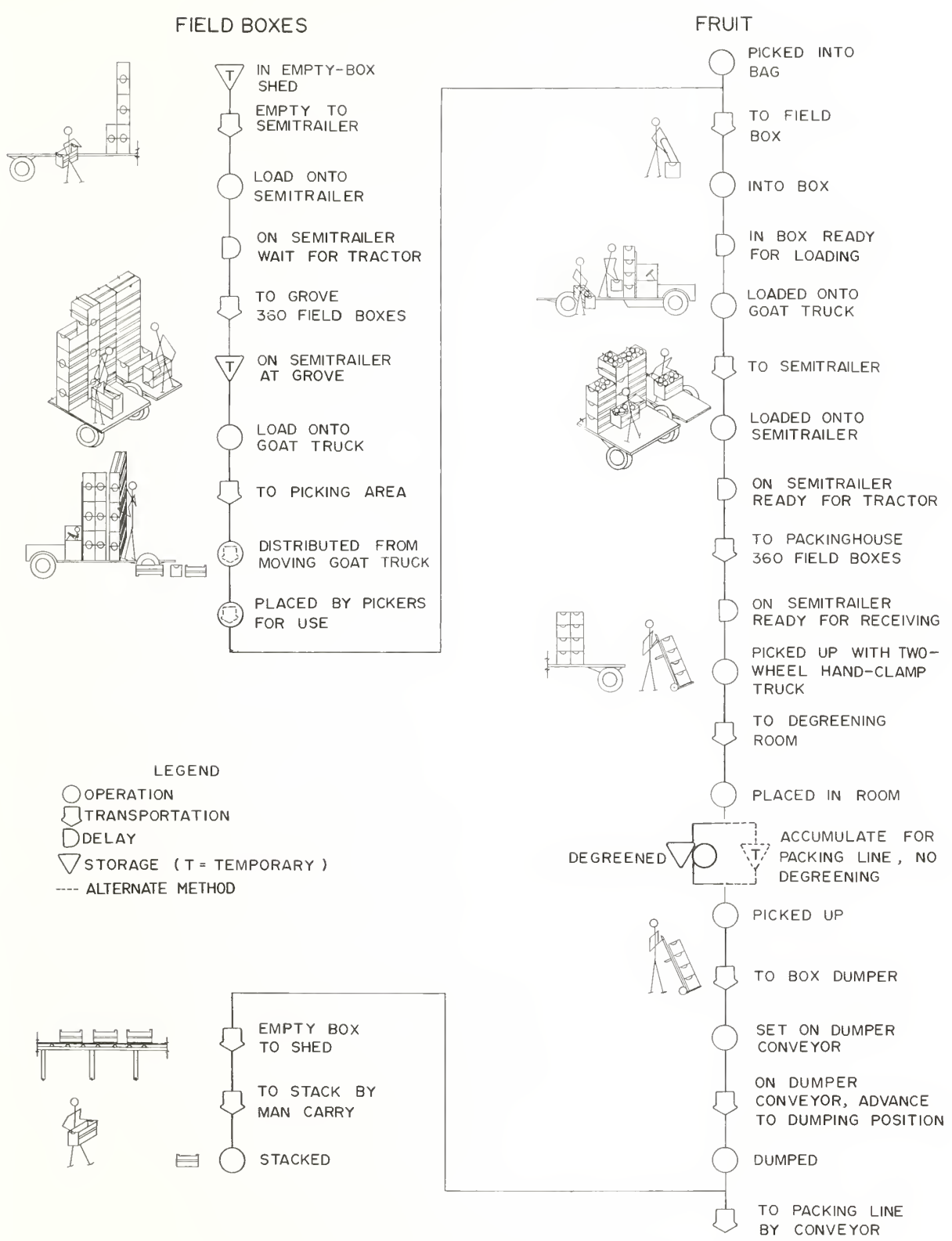


FIGURE 1.—Flow chart for field-box system.

where empty boxes are unloaded for movement to the pickers and boxes coming from the pickers are loaded onto the semitrailer for movement to the packinghouse on the return trip.

Between the transfer point and the pickers the field boxes are moved on a goat truck. It is often only the chassis with a seat for the driver and a flatbed, which is a little wider than the chassis. Some firms provide goat trucks with cabs and additional refinements.

The workers who go with the goat truck are called loaders, and their job is the most rigorous physically of any in the picking-to-packing-line handling of citrus. Empty boxes are pushed or tossed from the goat truck as it is driven along the rows or "middles" in the grove to distribute them near the pickers. The pickers move the boxes from the goat-truck route and place several together with sides in contact. When his picking bag is full or when he has cleaned a tree, the picker walks to the boxes, releases the cord to open the bottom of the picking bag, and deposits the fruit in the boxes. Unless several boxes are placed together, a considerable number of fruit will fall on the ground.

To pick up the filled boxes, the goat truck is driven over the same route as when empty boxes were distributed. The loaders lift the filled boxes from the ground to the goat truck and stack them, usually four high. Gross weight of a field box filled with fruit will average approximately 105 to 110 pounds. At the transfer point the filled boxes are moved manually to the semitrailer, one at a time, and are lifted again to stack them four high.

The number of boxes of fruit in a goat-truck load will vary depending on the size of the equipment. Smaller goat trucks will haul approximately 40 filled field boxes and the larger ones may haul as many as 60 or 70. Likewise, the size of the semitrailers may vary, but from 325 to 360 filled field boxes per load is typical. Highway loads legally cannot exceed 8 feet in width (*2*). Three rows of 33-inch-long field boxes are not possible. The invariable compromise has been to have a double row of field boxes down the center alined lengthwise. This loading pattern is a formidable obstacle to efficient lift-truck unloading. More empty boxes than filled ones are usually hauled on both goat trucks and semitrailers.

The boxes of fruit may be unloaded from the semitrailer at the packinghouse by means of a two-wheel hand-clamp truck, which transports four boxes or one stack on each trip to the degreening room. However, several packinghouses have replaced hand-clamp trucks with powered lift trucks equipped with a clamp for handling field boxes—usually 16 boxes per trip. A ground-level unloading area is needed for this operation; however, if the degreening rooms are at dock height, transfer to a second lift truck at dock height is necessary.

After the fruit is degreened, the filled field boxes are again moved by means of hand-clamp trucks or powered clamp-lift trucks to the dumper conveyor. This floor-chain conveyor is geared with the dumper to move stacks four boxes high into the dumper as needed. Fruit is dumped from the boxes onto a conveyor in a continuous automatic operation.

Empty field boxes are ejected onto a conveyor from the dumping machine and are transported in this way to the box shed, where they are manually stacked one at a time. Empty boxes may be manually loaded directly from the conveyor belt onto a semitrailer or truck for another trip to the grove. Otherwise they are loaded from the floor of the box shed when needed again.

Labor and Equipment

Labor requirements for the field-box system are given in table 1. The number of pickers for a given weekly output is derived from a picking rate of 10 boxes per man-hour actual picking time as a fair average for oranges and grapefruit. This is based on other research, as well as the study during 1959–61 concerned primarily with pallet-box handling of fresh fruit (*4*, *15*). Information on picking rates has also been obtained from various firms during work related to citrus handling systems over several years.

One picking foreman is assigned to each crew of 20 pickers. Furthermore, for crew members other than the packinghouse receiving foreman and the box-dumper operator, for each of which only one is allowed at all output levels, the requirements are based on results of work-sampling

TABLE 1.—*Field-box system: Labor requirements for picking-to-packing-line handling of citrus at specified boxes per week*

Worker identity	Workers required for—		
	8,000 boxes per week	16,000 boxes per week	24,000 boxes per week
Grove:			
Picking foreman	1	2	3
Pickers	20	40	60
Loaders [1]	6	10	14
Road transport, semitrailer-tractor driver [2]	1	2	3
Packinghouse:			
Receiving foreman	1	1	1
Receiving helper	†1	†1	†1
Truckers [3]	*2	*4	*6
Clamp-lift truck operators [4]	†2	†2	†3
Box-dumper operator	1	1	1
Empty-box handler	1	2	3
Total: [5]			
Hand-clamp truck	33	62	91
Clamp-lift truck	34	61	89

[1] Number based on 2 men with goat truck, 52 boxes per goat-truck load, 364 boxes per semitrailer load, 2,112 feet between picking area and transfer point, and additional 350 feet in picking area for loading filled boxes and distributing empty boxes.

[2] Number based on 15 miles between transfer point and packinghouse. Each driver has tractor and complement of 3 semitrailers.

[3] Number based on moving stack of 4 boxes at a time on hand-clamp truck and 150 feet round trip between semitrailer and degreening room and degreening room and box-dumper conveyor.

[4] Number based on 16 boxes per load on powered clamp-lift truck and same travel distance as for hand-clamp truck.

[5] Select total depending on truck equipment used (*=hand-clamp truck; †=powered clamp-lift truck).

studies by Thor [4] and time studies made during the period covered by this report.

Manpower need in terms of number of workers for each activity is shown. Equipment requirements are derived essentially from worker requirements because of the worker-equipment interdependence in the given operations. Information on the amount of equipment needed may be based on the number of workers and other data in table 1. The equipment is listed in tables 13 and 14 (appendix).

[4] See footnote 3, page 4.

Special considerations are involved where clamp-lift trucks are used instead of hand-clamp trucks. Openings for the clamp arms need to be made between stacks of boxes on the truck bed by a worker other than a clamp-lift truck operator so that the clamp can grasp a unit load of 12 or 16 field boxes (fig. 2).

When the truck is loaded for transport from the grove to the packinghouse, stacks of boxes are customarily pushed as close together as possible. Usually there are boxes along the center of the truck bed, filling space between boxes along each side. The latter are placed with outer ends almost flush with the edge of the truck bed. The

PX–1893

FIGURE 2.—Making space between field boxes with pry bar to permit entry of clamp on lift truck for unloading boxes of fruit.

center boxes are moved manually with a pry bar or similar tool so they can be picked up by the clamp-lift truck (fig. 3). This prying operation materially increases the wear and tear on the field boxes.

Unfortunately adoption of the clamp-lift truck for handling incoming boxes at the packinghouse requires a receiving helper for the manual prying apart and positioning of stacks of boxes on the truck or semitrailer. Thus a part of the potential labor saving will not be realized, except where road truck drivers stay with their vehicles during unloading and thereby do the positioning work without needing an additional worker.

Manpower requirements in table 1 do not reflect the theoretical difference between using hand-clamp trucks and powered clamp-lift trucks because the computed number of clamp-lift trucks was "rounded off" to a higher figure.

Costs

The average costs of handling oranges by the field-box system are shown in table 2. These include both annual fixed or overhead costs, which on a per-box basis decrease as volume increases, and direct costs, which are constant for each box handled regardless of volume. These two costs make up the total cost per box handled. The relationship between the total cost per box and the annual volume handled is not direct but curvilinear as shown in figure 4. Table 15 (appendix) gives additional details of these costs.

The costs shown are developed on the assumption that receiving at the packinghouse is by clamp-lift truck and boxes are dumped on the packing line by an automatic "stack dumper."

At present labor rates, use of hand-clamp trucks in the packinghouse costs slightly less per box than clamp-lift trucks. The increase in fixed costs of clamp-lift trucks over hand-clamp trucks is not entirely offset by the saving in labor. However, at the rate of 16,000 boxes handled weekly and 400,000 boxes annually, clamp-lift trucks increase handling costs by only $0.0067 per box over hand-clamp trucks. Moreover, the full amount for the receiving helper is included in the clamp-lift truck expense, as well as potential additional capacity due to rounding off the number of these trucks.

PN–1894

FIGURE 3.—Clamp-lift truck and semitrailer at packinghouse with fruit-filled field boxes placed lengthwise in center of load.

TABLE 2.—*Field-box system: Total annual fixed and direct costs for picking-to-packing-line handling of oranges at various weekly and annual volumes*

Weekly volume and costs	Average cost per box for annual volume of—						
	100, 000 boxes	200, 000 boxes	300, 000 boxes	400, 000 boxes	500, 000 boxes	600, 000 boxes	700, 000 boxes
8,000 boxes							
Fixed	$0. 1790	$0. 0895	[1]				
Direct	. 4669	. 4669	[1]				
Total	. 6459	. 5564	[1]				
16,000 boxes							
Fixed	. 3437	. 1718	$0. 1145	$0. 0859	$0. 0687	[1]	
Direct	. 4550	. 4550	. 4550	. 4550	. 4550	[1]	
Total	. 7987	. 6268	. 5695	. 5409	. 5237	[1]	
24,000 boxes							
Fixed	. 5085	. 2542	. 1695	. 1271	. 1017	$0. 0847	$0. 0726
Direct	. 4600	. 4600	. 4600	. 4600	. 4600	. 4600	. 4600
Total	. 9685	. 7142	. 6295	. 5871	. 5617	. 5447	. 5326

[1] Maximum that can be handled annually is less than this volume.

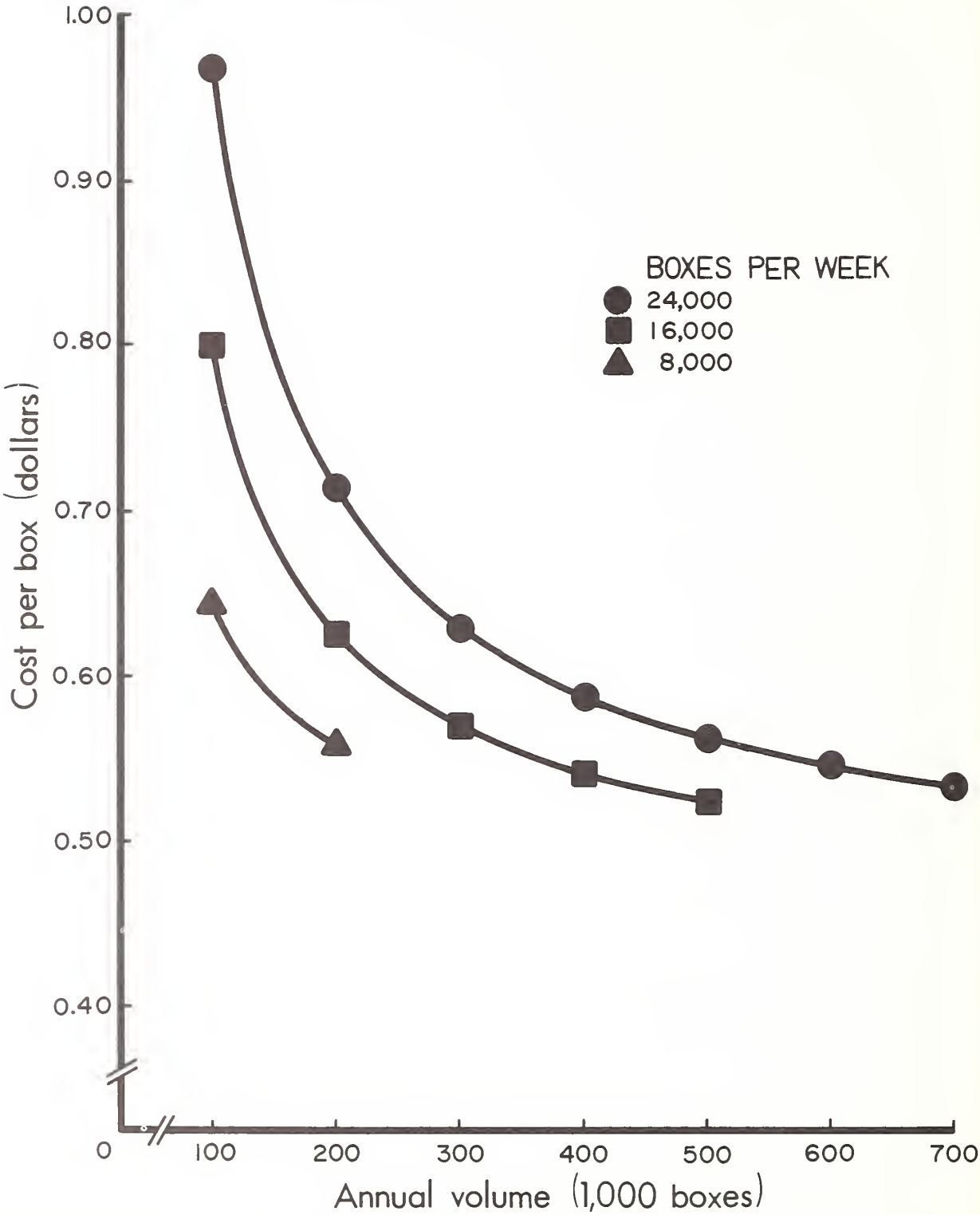


FIGURE 4.—Effect of annual volume on total cost per box for picking-to-packing-line handling of citrus at three weekly output rates for field-box system.

FULL-BULK SYSTEM

Description

In the full-bulk system, which has been described in earlier reports (*10*, *14*), no individual containers are moved back and forth between the picker and the packinghouse. Two-wheel carts drawn by tractors are used in the grove as containers into which the pickers empty fruit from picking bags and in which the fruit is transported from the picking area to the transfer point. The carts have a capacity equivalent to 25 field boxes. Instead of a flatbed semitrailer, a bulk semitrailer with side boards and end gate is used. A flow chart for the system is shown in figure 5, and the activities in the chart are summarized in table 23 (appendix).

At the transfer point a specially constructed mobile elevator is used for transferring fruit from the two-wheel cart to the bulk semitrailer (fig. 6). Fruit pours from the rear end of the cart by gravity when the end gate is opened and the cart is raised at the other end by the drawbar lift mechanism of the tractor.

In handling fruit for the fresh market, a bulk semitrailer usually hauls a load equivalent to about 325 field boxes. Prosser et al. (*11*) advised carrying only 320 boxes when handling fresh fruit in a bulk semitrailer to reduce damage from sheer weight of the fruit, although the full-load capacity available when hauling fruit for processing was 420 boxes. As a general rule, no more than 10 boxes per foot of trailer length should be carried, and damage can be minimized by loading this with an "angled" chute (fig. 7), which insures an almost flat load.

At the packinghouse a sloping driveway tilts the semitrailer toward one side so that fruit will pour out when doors along the bottom of that side are opened. Removable plates resting on the conveyor framework are pushed into contact with the side of the trailer directing the fruit onto the conveyor, which runs parallel with the driveway. For optimum cost effect the conveyor system should include a presizer and a pregrading station.

After this horizontal movement, bucket elevators carry the fruit to the top of the special bin structure, one of the primary and distinctive components of the full-bulk system (*6*, *11*). Horizontal conveyors move the fruit to any given bin, where it is diverted from the belt for gravity flow into the bin. A baffle system in each bin protects the fruit against mechanical injury when filling the bin. The bin bottom slopes so that when doors are opened the fruit will flow out by gravity to a conveyor, which moves it to the packing-line entry point.

The special bins include steam radiators, air ducts, humidifiers, and fans for supplying warm air as required, together with equipment for adding ethylene gas for degreening in these bulk bins.

Labor and Equipment

Labor requirements for the full-bulk system are shown in table 3. The number of pickers for a given output per week is derived from a picking rate of 10 boxes per man-hour as explained for the field-box system.

One picking foreman is assigned to each crew as for the other three systems. The manpower requirements for grove tractor drivers and semitrailer drivers are based on time-study data obtained during this study. For the receiving foreman and operators of the bulk bin-to-packing-line supply, the relationships are based on long experience of a representative firm and the physical arrangement of its facilities.

Equipment requirements are based on the number of workers and other data in table 3. The equipment is listed in tables 13 and 16 (appendix).

A unique feature of this system is provision for presizing and pregrading fruit before degreening. The necessary machinery for presizing is built into the conveyor line that moves fruit to the bins.

Pregrading also requires additional machinery on the conveyor line in the form of a grading table, but it requires the attention and hands of people. Thus labor requirements are greater with pregrading—normally two workers and possibly four depending on the condition and desired rate of flow

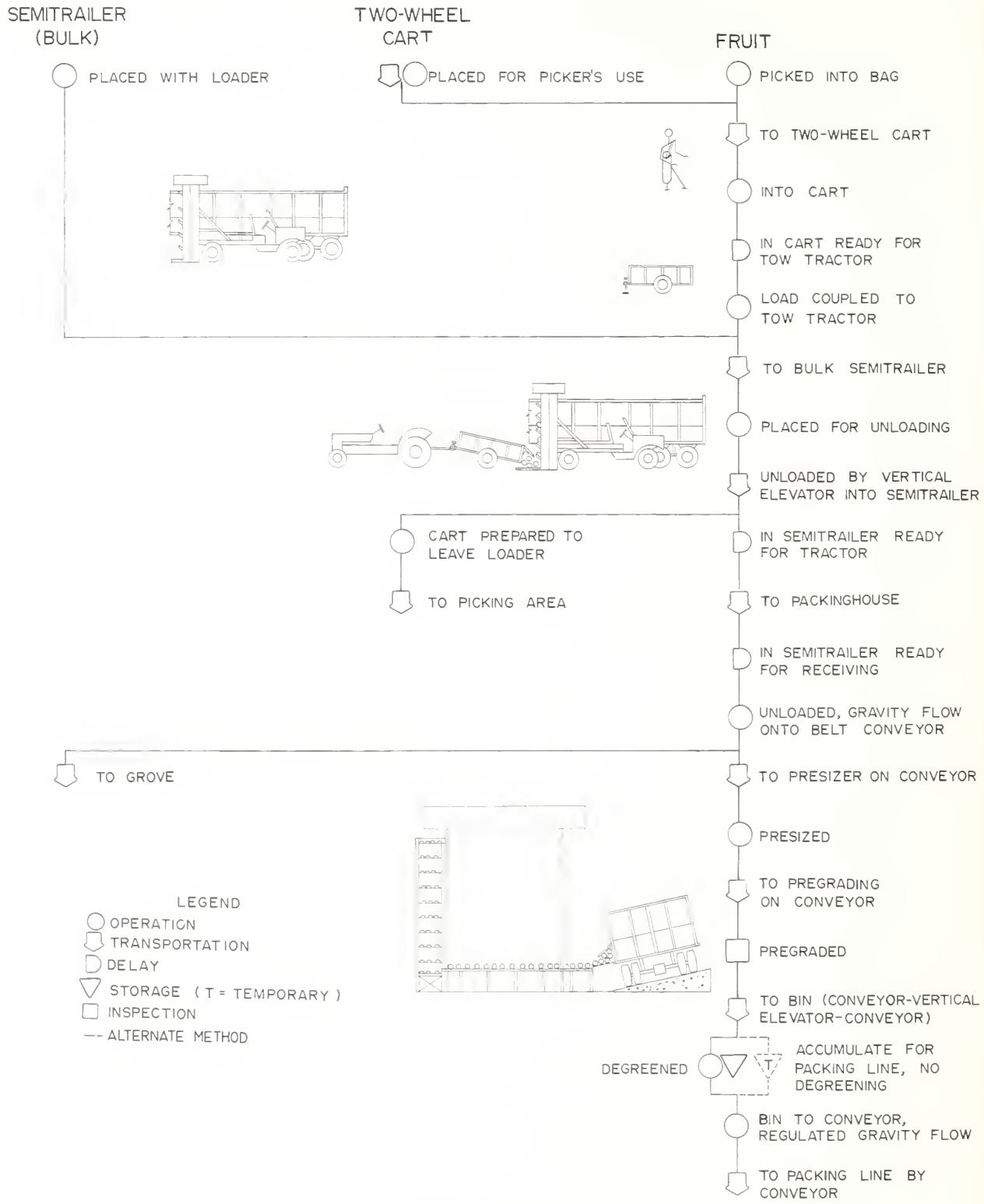


FIGURE 5.—Flow chart for full-bulk system.

TABLE 3.—*Full-bulk system: Labor requirements for picking-to-packing-line handling of citrus at specified boxes per week*

Worker identity	Workers required for—		
	8,000 boxes per week	16,000 boxes per week	24,000 boxes per week
Grove:			
Picking foreman	1	2	3
Pickers	20	40	60
Tractor drivers [1]	3	6	9
Road transport, semitrailer-tractor driver [2]	1	2	3
Packinghouse:			
Receiving foreman	1	1	1
Receiving operator	1	1	1
Operators, bin-to-packing-line supply	2	2	2
Total	29	54	79

[1] Number based on towing 1 cart at a time to and from transfer point, 25 field-box equivalents per load, 2,112 feet between picking area and transfer point, and additional 600 feet for moving carts in grove.

[2] Number based on 15 miles between transfer point and packinghouse and 325 field-box equivalents per load in 34-foot semitrailer. Each driver has tractor and complement of 3 semitrailers.

PN–1895

FIGURE 6.—Mobile bucket elevator beside bulk semitrailer, and cart filled with fruit in place for unloading.

of the fruit. This does *not* however represent extra labor. Somewhere between receiving "grove-run" fruit and shipping, all blemished fruit has to be removed manually. Doing this as part of the receiving operation decreases the load on the packinghouse machinery, increases packout of all fruit handled in the packinghouse, and gets eliminated fruit to the cannery "grove run" rather than as degreened, washed, and waxed eliminations.

Thus labor requirements in table 3 do not include workers for pregrading because the operation is not normally a part of other systems. Equality in comparison of costs dictates this approach. Special analyses can be done to include the cost of pregrading.

Costs

The average cost of handling oranges by the full-bulk system is shown in table 4. Included are both fixed costs for equipment required and direct costs for equipment and labor. As total annual volume increases at a given weekly output, direct costs remain constant for the same weekly volume. Since fixed costs per box decrease, total costs also decline. Table 17 (appendix) gives additional details of these costs.

The ultimate cost per box handled is dependent

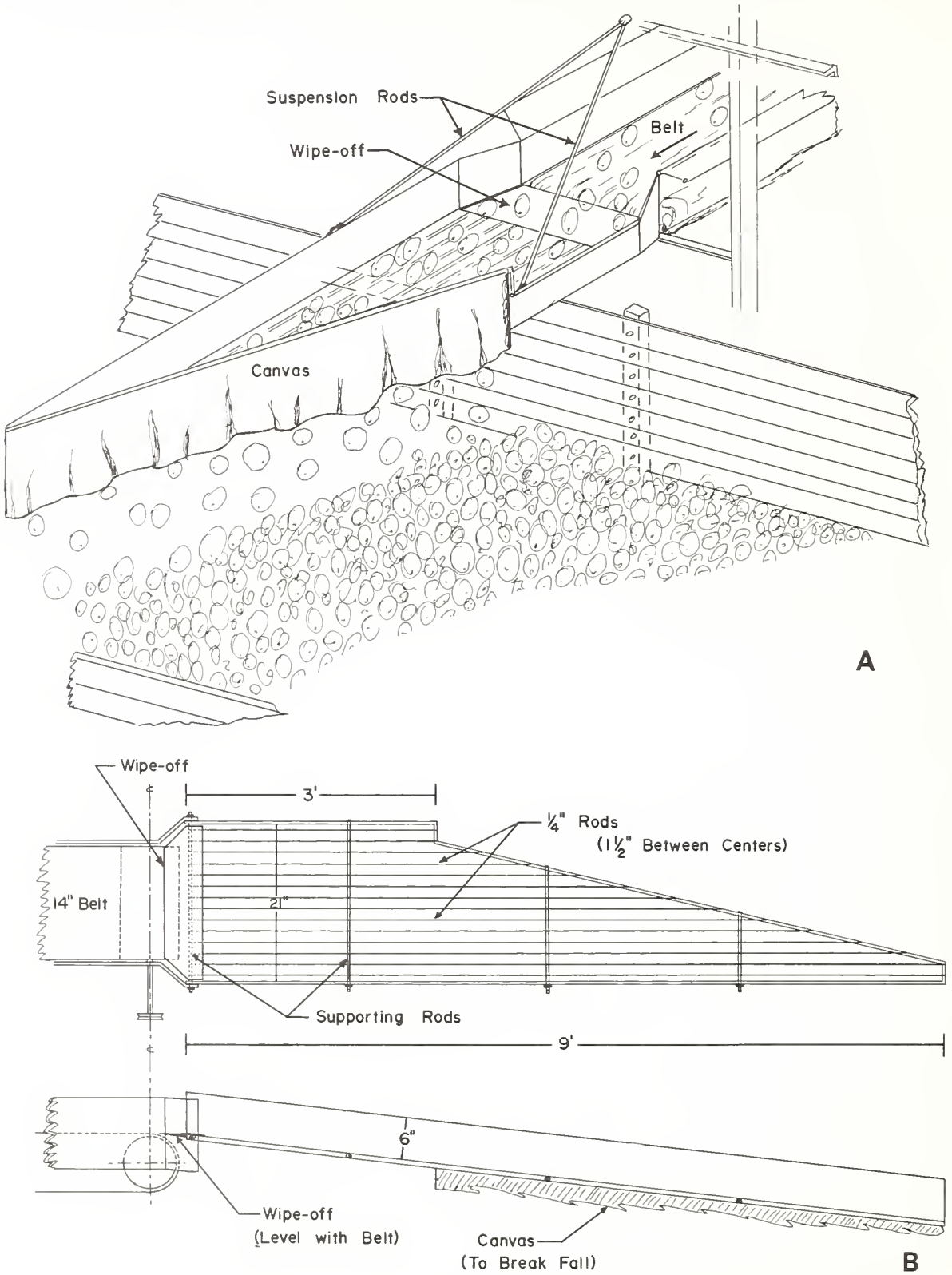


FIGURE 7.—Construction details of "angled" chute attached to vertical elevator for bulk loading of fruit into semitrailer.

TABLE 4.—*Full-bulk system: Total annual fixed and direct costs for picking-to-packing-line handling of oranges at various weekly and annual volumes*

Weekly volume [1] and costs	Average cost per box for annual volume of—						
	100,000 boxes	200,000 boxes	300,000 boxes	400,000 boxes	500,000 boxes	600,000 boxes	700,000 boxes
8,000 boxes							
Fixed	$0.1277	$0.0638	[2]				
Direct	.4121	.4121	[2]				
Total	.5398	.4759	[2]				
16,000 boxes							
Fixed	.2432	.1216	$0.0810	$0.0608	$0.0486	[2]	
Direct	.4010	.4010	.4010	.4010	.4010	[2]	
Total	.6442	.5226	.4820	.4618	.4496	[2]	
24,000 boxes							
Fixed	.3577	.1788	.1192	.0894	.0715	$0.0596	$0.0511
Direct	.3973	.3973	.3973	.3973	.3973	.3973	.3973
Total	.7550	.5761	.5165	.4867	.4688	.4569	.4484

[1] Field-box equivalents.
[2] Maximum that can be handled annually is less than this volume.

not only on the volume but how close that volume is to the capacity of the equipment used. Thus at an annual volume of 700,000 boxes and 24,000 weekly, total costs per box were $0.1277 less than a similar size firm handling 200,000 boxes, but only $0.0275 less than a firm equipped to handle 200,000 boxes annually and 8,000 weekly.

At 16,000 boxes weekly and 400,000 annually, costs per box for the full-bulk system were $0.0791 less than the field-box system. A large part of the saving was in the cost of field boxes, although less labor was required for the bulk system. At a volume of 500,000 boxes annually, the full-bulk system offers savings of $46,000 over the field-box system.

Large items of expense for the bulk system were the initial cost and the maintenance of the degreening bin. No provision was made for scales in costing this system. Many organizations might find scales necessary to account for an individual grower's fruit. Otherwise there is no way to measure fruit received by the packinghouse, such as is provided by the field-box or pallet-box system.

Changes in total cost per box with increasing annual volume are shown for three weekly rates of output in figure 8.

PALLET-BOX SYSTEM

Description

The sequence of operations for the pallet-box system is similar to that for field boxes, as may be seen from the flow chart in figure 9. Activities in the chart are summarized in table 24 (appendix).

Empty boxes are stored during off-season in the degreening rooms and open areas within the packinghouse as space permits because special storage sheds are not provided.

Forklift trucks are used at the packinghouse to load the empty pallet boxes on semitrailers or trucks for transport to the transfer point near the grove. The boxes are usually handled in stacks of two when placed on the semitrailer and may be moved in stacks of four from the empty-box holding area to the semitrailer loading area (fig. 10).

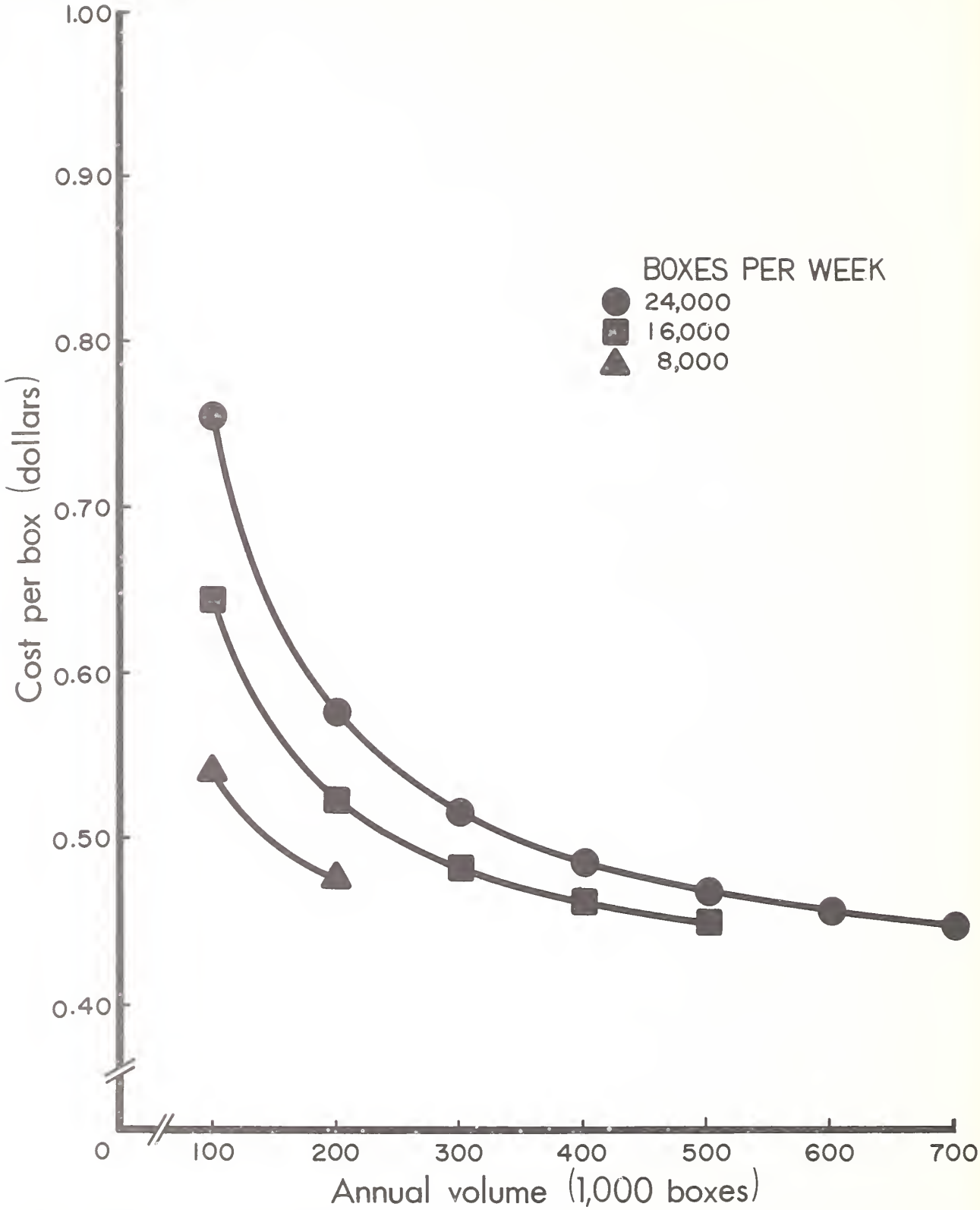


FIGURE 8.—Effect of annual volume on total cost per box for picking-to-packing-line handling of citrus at three weekly output rates for full-bulk system.

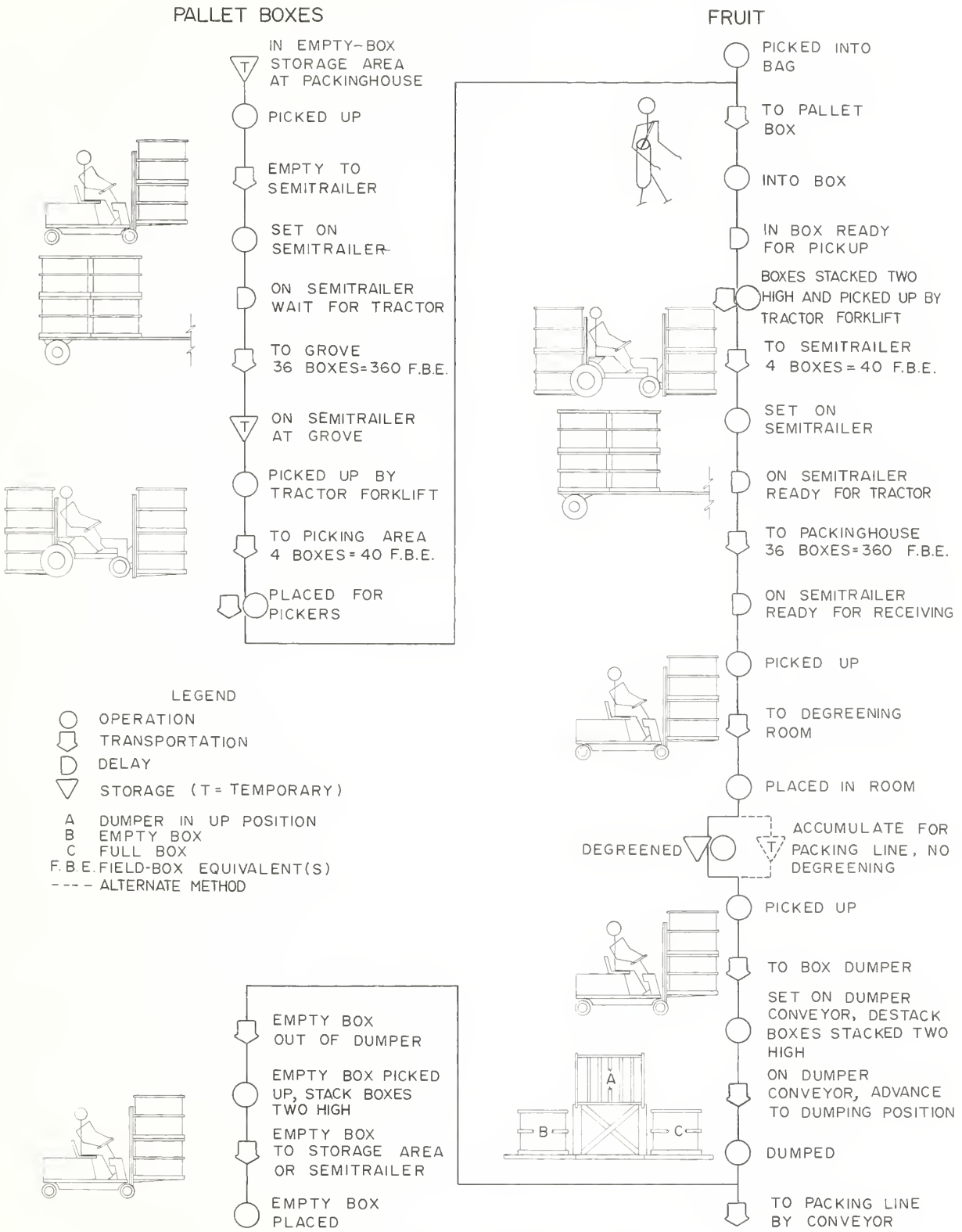


FIGURE 9.—Flow chart for pallet-box system.

PN–1896

FIGURE 10.—Empty-box holding area, showing boxes stacked four high.

At the grove transfer point, tractor-forklift equipment is used by some firms. Others use a boom-type unit, which lifts the boxes from the top to transfer them from the flatbed trailer to the goat truck.

As with field boxes, the pallet boxes must be transported to the picking area, distributed to the pickers, picked up after filling, transported back to the transfer point, and finally placed on a semitrailer for delivery to the packinghouse.

In earlier research, tractor-forklift units with a mast and forks on both ends were used in the handling and movement of boxes in the picking area and between that area and the transfer point (fig. 11). This equipment has not been used in commercial installations of the pallet-box system. Commercial firms mainly employ an industrial-type tractor forklift in conjunction with a flatbed goat truck or a flatbed goat truck on which is mounted a boom-type lift.

A further development in the flatbed goat truck with the tractor forklift is the installation of powered drag chains in the bed of the truck. The chains move the boxes forward from the rear when loading filled boxes and in the opposite direction when distributing empty boxes in the picking area or unloading at the transfer point. The tractor forklift and the goat truck together transport 10 pallet boxes, or 100 field-box equivalents, when moving fully loaded between the picking area and the transfer point. A goat truck with a boom lift transports a maximum of eight pallet boxes, or 80 field-box equivalents, between these two places.

Prevailing practice is to have pallet boxes stacked two high on the flatbed semitrailer, with two rows the full length of the bed. Thus 32, 36, or 40 pallet boxes, depending on the length of the semitrailer, comprise a load. A 40-foot semitrailer will accommodate a similarly arranged load of 40 pallet boxes.

A straddle-trailer unit for transporting pallet boxes between the grove transfer point and the packinghouse is used by at least one large cooperative. The unit is essentially a semitrailer of special construction—a frame that permits straddling the load and powered mechanism for gripping, raising, and lowering the load. Thus far the load capacity has been 32 pallet boxes, or equivalent to 320 standard field boxes. Its limited acceptance has been largely due to the custom of hauling a considerable proportion of the crop over distances too great to utilize effectively the "quick turn around" feature of this trailer.

Almost without exception the pallet boxes in use have a capacity equivalent to 10 field boxes.

At the packinghouse filled boxes of fruit are moved from the semitrailer to the degreening room by forklift trucks and then in the same manner from the degreening room to the pallet-box dumper.

This dumping machine is essentially a unit with a "cradle" for holding the box. The cradle is powered through a hydraulic or mechanical sys-

tem by an electric motor. Two types of automatic control are common and both are built into modern automatic dumping systems. The first is speed control on the dump cycle. The second is a system of limit switches that automatically delivers full boxes from a powered chain. A further refinement is the incorporation of automatic destacker and restacker units. These pieces of equipment are worthwhile when they reduce the number of forklift trucks needed. Some dumping machines turn the box completely upside down, possibly rotating it 360° (fig. 12). Other machines only move the box through an arc of approximately 120° when emptying the fruit from the container (fig. 13).

The fruit may be dumped from the box into a water tank rather than onto a belt conveyor, whichever is preferred by the packinghouse. Water tanks are a serious decay hazard unless a fungicide solution approved by the U.S. Food and Drug Administration is used. Powered conveyors that move the pallet boxes into and out of the box dumper eliminate much of the manual work. Handling efficiency with this system is much higher than with the field-box system.

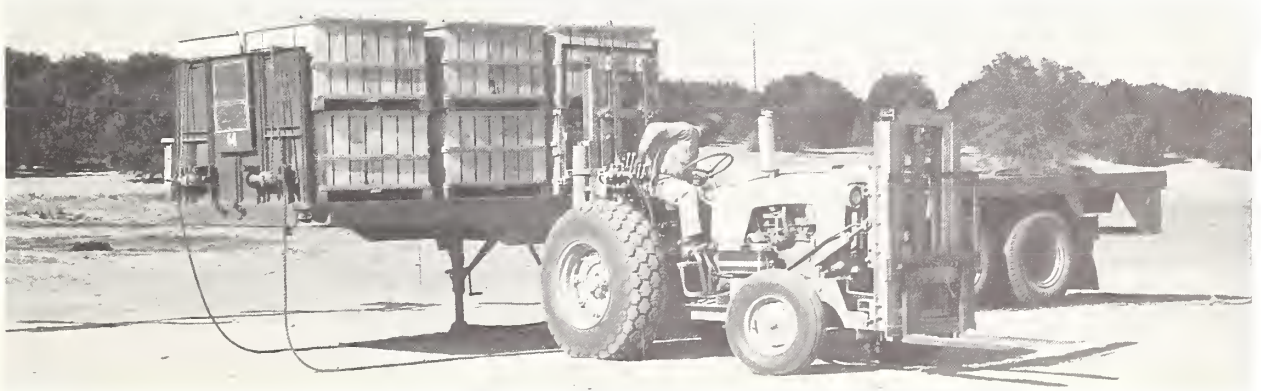
Labor and Equipment

Labor requirements for the pallet-box system are shown in table 5. The number of pickers for a given output per week is derived from a picking rate of 10 boxes per man-hour as already explained.

Each picking crew is assigned a picking foreman as for the other three systems. The manpower requirements for tractor-forklift operator, goat-truck driver, and semitrailer-tractor driver are based on time-study data obtained during an earlier study. For the receiving foreman and pallet-box dumper operator, the number is based on experience of representative firms. The number of forklift-truck operators is based on time-study data obtained during this study and earlier standard-time data developed jointly by the Yale and Towne Co. and the Wharton School, University of Pennsylvania.

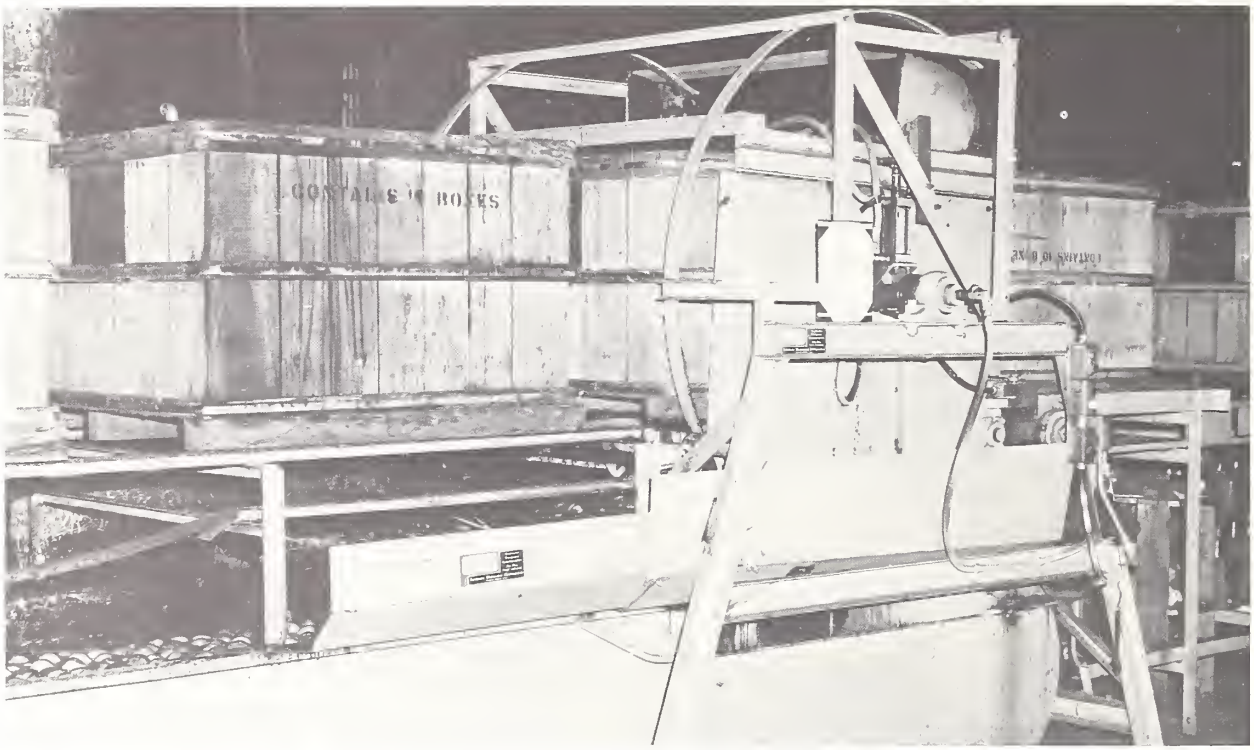
More than half the firms using pallet boxes thus far have chosen a boom-type lift mounted on a flatbed goat truck for handling and transporting boxes in the grove (fig. 14). One appealing feature has been its multifunction capability—one unit can transport eight pallet boxes as well as perform the necessary loading, unloading, and transferring of the boxes. When mounted on a modified "hi-lift" truck body, this equipment also is readily adapted to the handling of bulk fruit for the cannery, an important consideration, since most firms handle both fresh and cannery fruit (fig. 20). The boom lift can be easily adapted to handle different containers by using interchangeable heads or "grapples."

Tractor-forklift units are limited in transport capacity to two pallet boxes unless there is a mast and forks on both ends for transporting four boxes at a time (fig. 11). In many of the handling steps, however, the tractor forklift can move two boxes at a time, whereas the boom-type lift, because it grips the top edge of the box, is limited to one box. For example, a forklift can place two filled boxes on the goat truck and transfer both filled and empty boxes, two at a time, at the transfer point. All told, there is a rather complex interplay



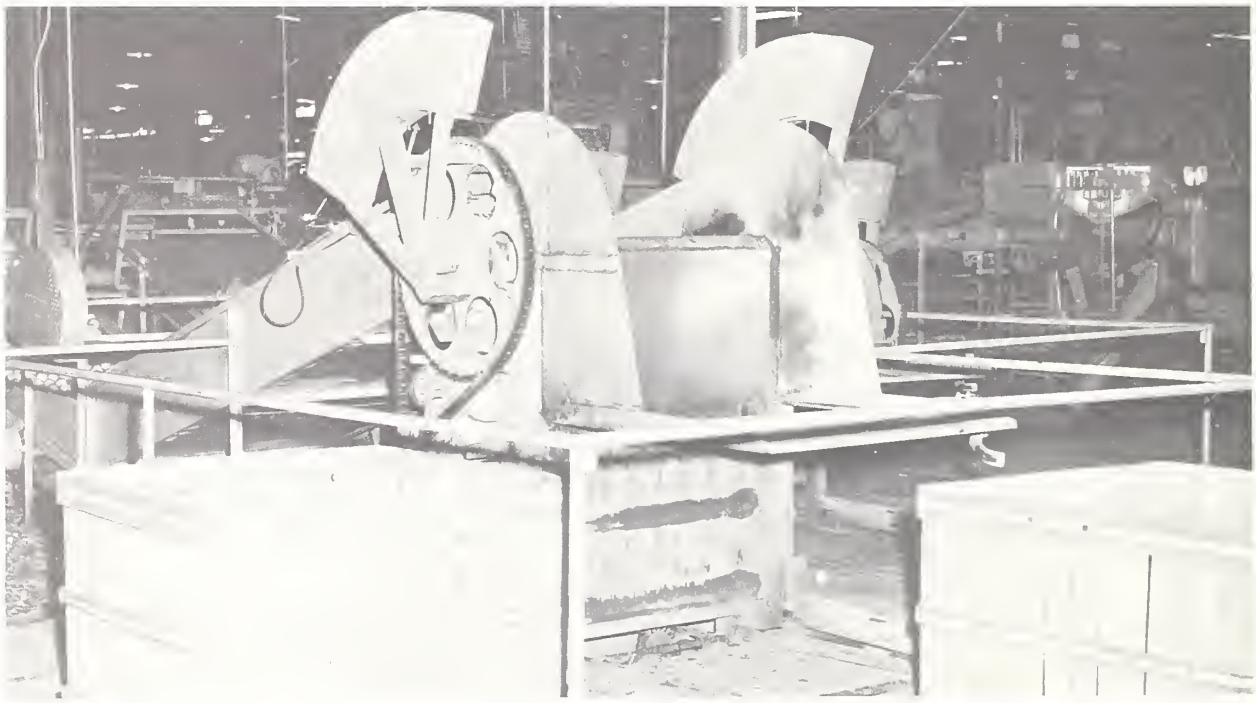
PX–1897

FIGURE 11.—Tractor-forklift unit equipped with mast and forks on both ends.



PN–1898

FIGURE 12.—Pallet-box dumper rotates cradle and box 360° and releases fruit into water tank when box is upside down.



PN–1899

FIGURE 13.—Pallet-box dumper tips box approximately 120° and releases fruit into chute (left background) and then onto roller conveyors.

TABLE 5.—*Pallet-box system: Labor requirements for picking-to-packing-line handling of citrus at specified boxes per week*

Worker identity	Workers required for—		
	8,000 boxes per week	16,000 boxes per week	24,000 boxes per week
Grove:			
Picking foreman	1	2	3
Pickers	20	40	60
Tractor-forklift operator [1]	1	2	3
Goat-truck driver [1]	1	2	3
Road transport, semitrailer-tractor driver [2]	1	2	3
Packinghouse:			
Receiving foreman	1	1	1
Forklift-truck operators [3]	2	2	3
Pallet-box dumper operator	1	1	1
Total	28	52	77

[1] Number based on tractor forklift and also flatbed drag chain-equipped goat truck used together handling 2 boxes on tractor forklift and 8 boxes on goat truck for each trip, 100 field-box equivalents per load, 2,112 feet between picking area and transfer point, and additional 350 feet in picking area for distributing empty boxes and picking up filled boxes.

[2] Number based on 15 miles between transfer point and packinghouse and 360 field-box equivalents per load in 36 pallet boxes on 36-foot semitrailer. Each driver has tractor and complement of 3 semitrailers.

[3] Number based on moving 2 boxes at a time except 4 per trip between empty-box holding area and loading point, 100 feet between empty-box area and loading point, 100 feet between unloading point and degreening room, and 80 feet between degreening room and dumper and dumper and empty-box holding area.

of favorable and unfavorable characteristics and factors for each of the two kinds of equipment.

In considering alternative choices of equipment such as the tractor forklift and the boom-type lift, the user should carefully analyze the information about each kind of equipment before he decides which one will best fit his needs.

Data show no difference in the number of units required for either type of equipment. That is, two goat trucks with boom-type lift are required in lieu of a tractor forklift and flatbed goat truck used together. Likewise, equal manpower is required to operate either type of equipment. A truck especially for transporting each tractor forklift between groves is an additional unit of equipment that should be mentioned although not used directly in handling fruit (fig. 15). At least one firm using the pallet-box system provides such trucks.

Special problems occur in groves where, because of a high water table, trees are grown on raised beds. These may have one row of trees per bed ("single bedded" or "swale system")[5] or as many as four rows of trees per bed.

In a single-bedded grove, typical of the Indian River area of Florida, the tractor forklift can be at a disadvantage as compared to the goat truck with boom lift. The pronounced slope of the ground down to the center of the "middle" causes the tractor forks to tilt when approaching to pick up boxes, whereas the boom may swing out to the box while the goat truck straddles the center of the "middle" to avoid tilting (fig. 16).

The boom lift grips and lifts the box by its top, whereas the forklift supports it from underneath. Different stresses are induced in a box depending on which kind of equipment is used. Whether this actually results in a significant difference in box maintenance and useful life is not known. How-

[5] For the swale system, the surface of the raised bed is are shaped rather than flat between water channels.

PN-1900

FIGURE 14.—Boom-type lift mounted on flatbed goat truck for handling pallet boxes.

ever, it is evident that the sides must be securely attached to a sufficiently rigid pallet base when the boxes are lifted by the top.

With the boom lift, the boxes are not placed as close together because of clearance needed for the grapple hook. With the forklift, close stacking is possible. This effect is normally noticed when the pallet boxes are released on a flatbed truck or semitrailer for transport. The extra 2 or 3 inches between boxes must be taken into account either in the width or the length of the load depending on which way the boxes are turned for release on the vehicle.

The equipment for the pallet-box system is listed in tables 13 and 18 (appendix).

The user of pallet boxes has a variety of commercially made types to consider. In Florida no citrus firm has yet entirely adopted either plywood or metal boxes. The wooden boxes that are used are predominantly the slatted, nailed type made by box companies using "mass production" methods, as machine nailing of wood parts. They are standard models with given options available to the purchaser. Most of them are bound with either a metal strap or wire completely encircling the box on each horizontal stay strip (fig. 17).

The "metal-bound" wooden box with slatted sides and bottom is strong, durable, and of moderate weight and price. However, even without unduly hard usage, stretching of the strap or wire has been noted. This condition requires repair before too much looseness develops at the corners of the box. Problems can multiply rapidly when the box is not held together tightly. Some of them are as follows:

(1) Increased swaying of the box sides causes increased stress in a "vicious circle" effect.

(2) Stacking of boxes becomes more difficult because looseness may allow the upper box to slip down inside the lower box, usually at one corner. This brings increased stress on corner fastenings, injury to fruit, and a tilted stack that will not handle well.

(3) Tilted stacks frequently damage boxes when forks of the handling equipment lift them.

(4) Any distorted shape of the pallet box puts a severe strain on the fruit with consequent increase in fruit damage and decay.

Newer pallet boxes have neither strap nor wire binding but are made with inside corner posts and U-bolt metal fastenings, which provide strength.

Further information on strength and durability of pallet boxes as related to types and features of construction has been published by the U.S. Forest Products Laboratory (*8*).

The dimensions of pallet boxes have varied for different firms as their adoption has proceeded.

The maximum legal width for highway transport equipment in Florida is 8 feet (*2*). Thus for two rows of boxes to stay within the 8-foot width, one horizontal dimension of the pallet box should be less than 48 inches since space between rows cannot be entirely eliminated. Other dimensions may be varied within a reasonable range, for example to provide for efficient utilization of space in existing degreening rooms. However, the height of the box should be kept low so the pickers can empty fruit from picking bags into pallet boxes without injuring the fruit and without undue physical effort in lifting.

Pallet boxes in use by nine firms had outside dimensions ranging from 45½ by 45½ by 31½ inches to 48 by 48 by 31 inches and corresponding inside dimensions ranging from 43 by 43 by 27 inches to 45½ by 45½ by 26 inches. Their inside volume ranged from 49,923 to 53,826 cubic inches calculated without allowance for headspace. In actual use some headspace is necessary to avoid injury to fruit when boxes are stacked. With these variations in dimensions of pallet boxes, a special effort was made to establish a pallet-box volume equivalent to 10 field boxes in accordance with industry preferences.

In a larger container, volume needed to provide fruit capacity equivalent to 10 field boxes, for example, is not simply 48,000 cubic inches—the exact multiple of field-box volume. The reason for this is that the density is greater in the larger container since there are only four bottom corners instead of 80 and fruit is approximately twice as deep.

Experiments were carried out with citrus and full-size boxes and with marbles and scale-model miniature boxes.[6] These experiments resulted in the following recommendations:

[6] Special assignment by the Florida Fresh Citrus Shippers Association to a committee composed of William Grierson, Scott Hedden, and Earl K. Bowman.

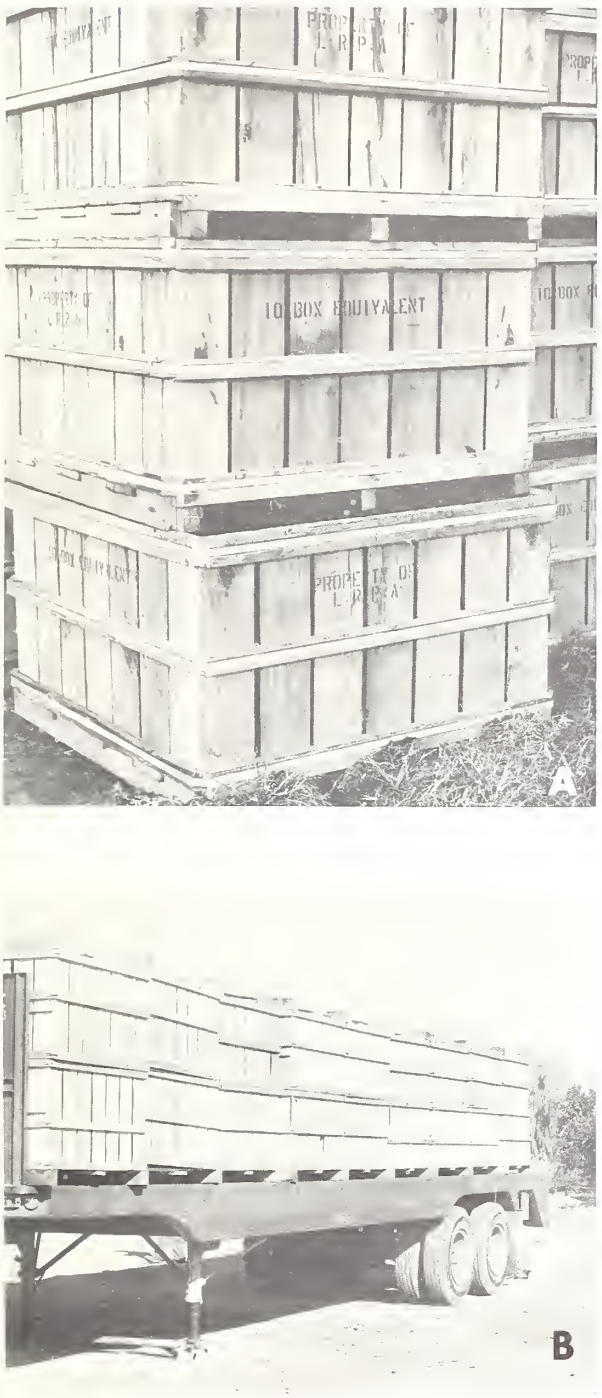
PN–1901

FIGURE 15.—Truck especially equipped to transport tractor-forklift unit between groves or between equipment storage, service headquarters, and grove areas. Fuel tank is attached to supply tractor forklift, and hand-operated pump (operating lever visible at right rear of cab) is provided to pump fuel into tractor-forklift tank.

"A container of capacity equivalent to 10 standard field boxes shall have external dimensions not to exceed 32 inches in overall height nor 47 inches in overall width and an internal volume to be filled with fruit of 43,500 cubic inches. Such containers for fresh fruit use should provide a headspace above the fruit of at least 2 inches to minimize fruit damage and to facilitate stacking and degreening. When a headspace is used, the level equivalent to 43,500 cubic inches shall be clearly marked inside the container on all four sides *or* all four corners."

PN-1902, PN-1903

FIGURE 16.—*A*, "Bedded" grove in Indian River area, showing sloping ground and tilted pallet boxes in place for pickers; *B*, grove not "bedded" in interior citrus area of Florida.



PN–1904, PN–1905

FIGURE 17.—Pallet boxes with metal strap (*A*) and wire (*B*) girdling boxes on each stay strip.

Using the box volume proposed by this investigation, comparable combinations of depth and other dimensions are shown in table 6. These measurements are within the external dimensions recommended by this investigation and compatible with the limitations on width of load for Florida highways. The 1½-inch thickness is to represent slatted box sides with stay strips or plywood sides and a strip around the top to permit top lifting.

Costs

The average cost per field-box equivalent for handling oranges by the pallet-box system is shown in table 7. Fixed costs for equipment and direct operating costs for equipment and labor are given. Fixed costs and total costs per box decrease with increases in annual volume. The direct costs remain constant for the same weekly volume, regardless of the total volume harvested annually. Table 19 (appendix) gives additional details of these costs.

At an annual volume of 700,000 boxes and 24,000 weekly, total costs per box were $0.1255 less than for a firm of the same capacity handling 200,000 boxes annually, but were only $0.0381 less than for a firm handling 200,000 boxes annually and 8,000 weekly.

At 16,000 boxes weekly and 400,000 annually, costs per box for the pallet-box system were $0.0866 less than for the field-box system. At a volume of 500,000 boxes annually, savings of $49,000 are indicated for the pallet-box system over the field-box system.

Cost figures are based on using tractor-forklift units and flatbed goat trucks (chain-conveyor bed) in the grove. In a modification of this system, goat trucks with mounted boom-type loaders are used in the grove for handling filled and empty boxes and transporting them between the picking area and transfer point.

Changes in total cost per box with increasing annual volume are shown for three weekly rates of output in figure 18.

TABLE 6.—*Pallet-box dimensions for fruit capacity equivalent to 10 field boxes* [1]

Box length and width (inches)		Area inside	Depth inside to provide volume for fruit [1]		Box depth [3]	
Outside	Inside [2]		Theoretical	Practical	Inside [4]	Outside [5]
		Square inches	*Inches*	*Inches*	*Inches*	*Inches*
48 by 47	45 by 44	1,980	21.97	22.0	24.0	29.0
47 by 47	44 by 44	1,936	22.47	22.5	24.5	29.5
47 by 46	44 by 43	1,892	22.99	23.0	25.0	30.0
48 by 46	45 by 43	1,935	22.48	22.5	24.5	29.5
46 by 46	43 by 43	1,849	23.53	23.5	25.5	30.5

[1] 43,500 cubic inches used as volume required for amount of fruit equal to that in 10 field boxes.
[2] Based on 1.5-inch wall thickness.
[3] Increase by 0.5 inch for boxes with inside corner posts.
[4] Allows 2-inch headspace.
[5] Allows 5 inches for pallet.

TABLE 7.—*Pallet-box system: Total annual fixed and direct costs for picking-to-packing-line handling of oranges at various weekly and annual volumes*

Weekly volume [1] and costs	Average cost per box for annual volume of—						
	100,000 boxes	200,000 boxes	300,000 boxes	400,000 boxes	500,000 boxes	600,000 boxes	700,000 boxes
8,000 boxes							
Fixed	$0.1319	$0.0659	(2)				
Direct	.4147	.4147	(2)				
Total	.5466	.4806	(2)				
16,000 boxes							
Fixed	.2369	.1184	$0.0789	$0.0592	$0.0473	(2)	
Direct	.3951	.3951	.3951	.3951	.3951	(2)	
Total	.6320	.5135	.4740	.4543	.4424	(2)	
24,000 boxes							
Fixed	.3514	.1757	.1171	.0878	.0702	$0.0585	$0.0502
Direct	.3923	.3923	.3923	.3923	.3923	.3923	.3923
Total	.7437	.5680	.5094	.4801	.4625	.4508	.4425

[1] Field-box equivalents.
[2] Maximum that can be handled annually is less than this volume.

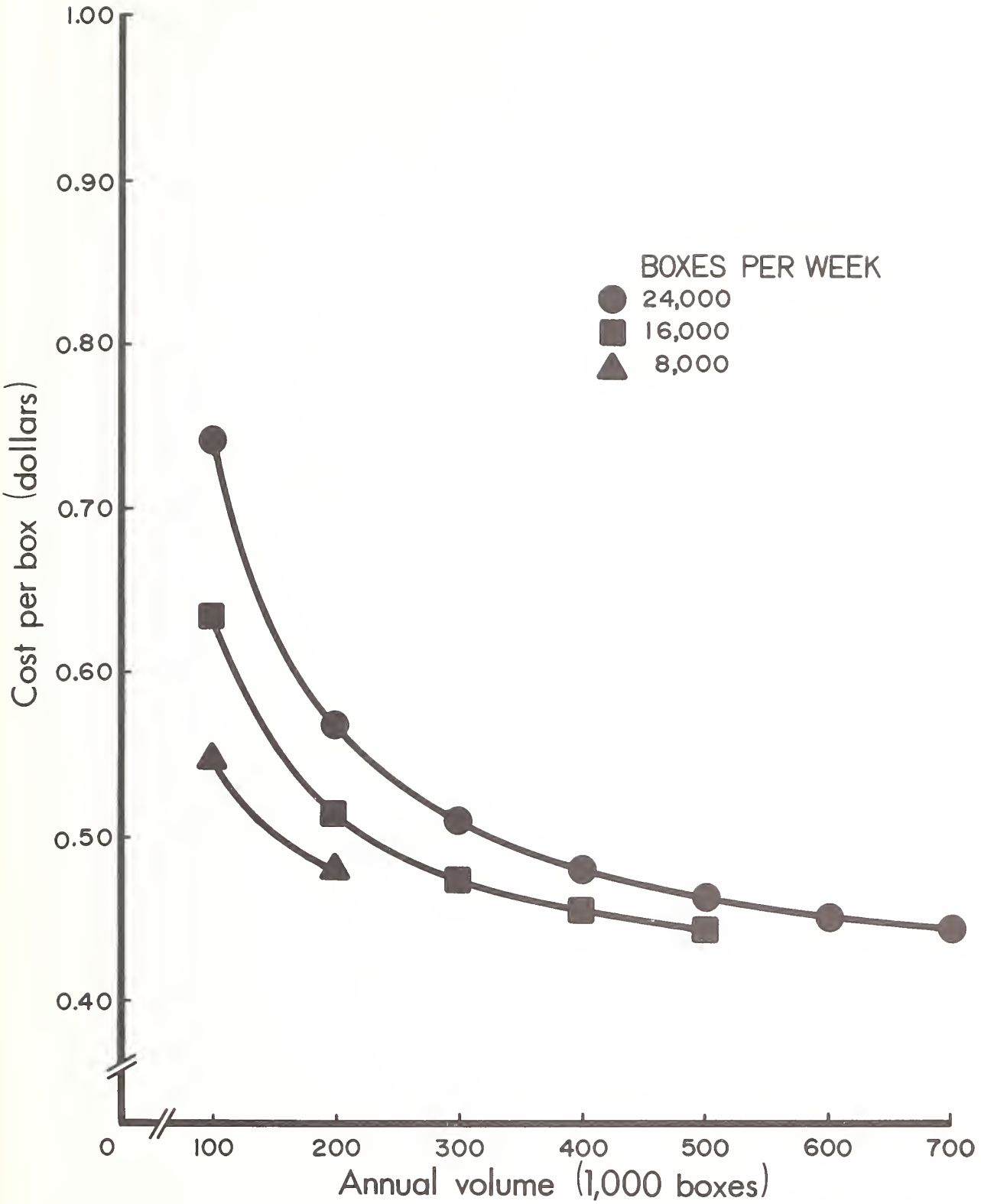


FIGURE 18.—Effect of annual volume on total cost per box for picking-to-packing-line handling of citrus at three weekly output rates for pallet-box system.

MODIFIED-BULK SYSTEM

Description

The modified-bulk system is a blending of the full-bulk and the pallet-box systems, as shown by the flow chart in figure 19. The activities in the chart are summarized in table 25 (appendix).

In the grove a bulk system is used, and fruit is moved from the grove to the packinghouse in bulk semitrailers like those used for the full-bulk system. Instead of the two-wheel carts in the grove, commercial installations of the modified-bulk system have used metal mesh containers, into which the pickers empty the fruit from their picking bags. These metal baskets are lifted by a boom-type loader, essentially the same as that described for the pallet boxes, which empties the fruit into a bulk-body goat truck (fig. 20).

These metal baskets are often identical to those used for fruit picked for the cannery. However, they should be constructed of tubular rather than angle iron framing around the top to minimize fruit damage. Some operators when working on loose sand place pieces of plywood on the ground, on which the basket is positioned for filling. The bottom of the metal basket is constructed to open by a control from the driver's position so that the fruit can be emptied from the metal basket into the bulk-body goat truck. Another version uses a wide plastic tub, which is easier for the picker to fill. However, it has to be tipped by the hydraulic hoist rather than emptied from the bottom. Interchangeable heads for the boom lift can be used to handle the plastic tub. The containers hold approximately 10 field-box equivalents of fruit. The bulk-body goat truck has a capacity of about 70 field-box equivalents per load.

The metal baskets are replaced in the same position after emptying by the boom lift if more fruit remains to be picked from the same trees. Otherwise baskets may be moved to other places where they are needed by the pickers. These containers are not moved to and from the packinghouse as are the pallet boxes.

The bulk-body goat truck is equipped with a powered high-lift mechanism, and one side of the truck is hinged so that fruit can be emptied into the bulk semitrailer at the transfer point.

A "fresh fruit hi-lift" differs from a purely cannery version in that the mechanism includes an extra set of hydraulic cylinders, which enables the body to be raised to any height and then tipped slowly, rather than being tripped by a cam at the maximum lift height. The driver positions the goat truck close alongside the semitrailer and operates controls to elevate the body to a sufficient height for fruit to pour out through the side opening into the semitrailer.

Two alternate types of fresh-fruit modifications are used on these "fresh fruit trailers." Either the side hinges down to an initial 2 feet and raises to 4 feet as the load accumulates, or the trailer body has two layers of webbing baffles that cushion the initial fall and carry much of the weight of the fruit during road transit. A semitrailer load is normally about 325 field-box equivalents of fruit.

At the packinghouse, unloading arrangements essentially similar to those described for the full-bulk system are provided. With suitable conveyors and equipment, the fruit may be presized and pregraded as for the full-bulk system. It is then either run directly onto the packinghouse lines or alternately accumulated in pallet boxes. From the point at which forklift equipment begins to move boxes to degreening rooms, the steps are the same as for the pallet-box system. Box dumping and related steps are also the same as for the pallet-box system.

One of the important advantages of the modified-bulk system is that the incoming stream of fruit can be divided at the pregrader. A low percentage of green fruit can be diverted to pallet-box degreening or the best colored fruit can be accumulated for a "natural color" order while the rest of the fruit goes directly to the packinghouse line.

Photoelectric sorting equipment at the pregrading station would eliminate additional labor for color sorting, and through further research and development this type of equipment may be employed to pregrade or sort out surface-defective fruit without manual labor.

Empty boxes are moved by forklift trucks from the dumper either to a temporary holding area until they are needed again at the box-filling stations or directly to the stations if they are needed immediately.

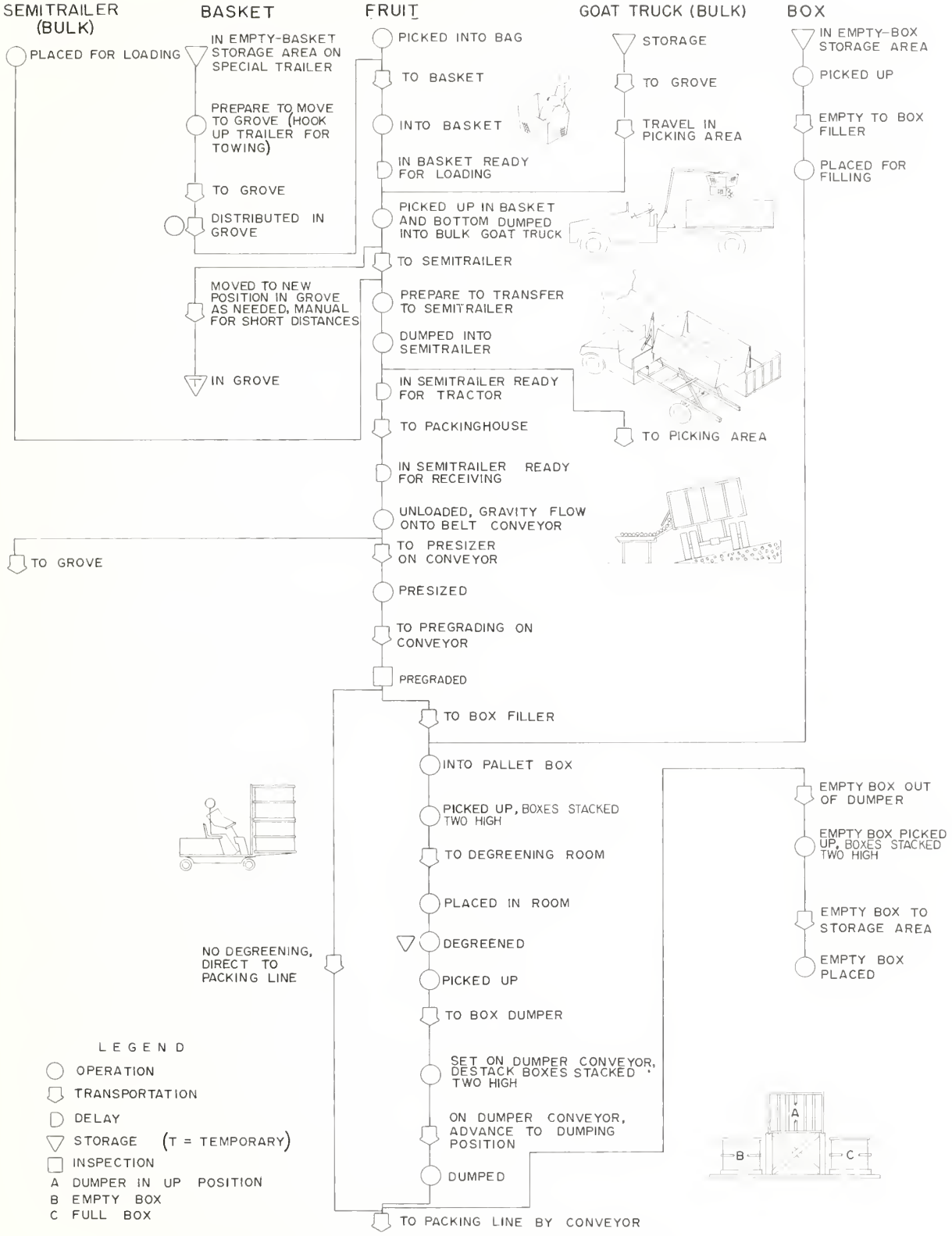


FIGURE 19.—Flow chart for modified-bulk system.

PX-1906

FIGURE 20.—Boom-type lift mounted on bulk-body goat truck for handling fruit in bulk after it is picked and put in dump-bottom metal mesh baskets.

Labor and Equipment

Labor requirements for the modified-bulk system are shown in table 8. The number of pickers is derived from a picking rate of 10 boxes per man-hour as for the other three systems.

Each crew is assigned a picking foreman as for the other three systems. The manpower requirements for bulk goat-truck drivers are based on time-study data obtained currently, and requirements for semitrailer-tractor drivers take into account both current and earlier work. For the receiving foreman, fruit receiver, pallet-box filler operator, and pallet-box dumper operator, the number is based on experience of representative firms. The number of forklift-truck operators is based on the time-study data obtained during this study and standard-time data previously developed jointly by the Yale and Towne Co. and the Wharton School, University of Pennsylvania.

The boom-lift equipment for use on a bulk goat truck is essentially the same as that used on a flatbed goat truck except it does not have as much "reach." The former costs about $1,000 less than the boom-lift unit on a flatbed goat truck in the pallet-box system. However, the "high-lift" mechanism that is a part of the bulk goat truck more than offsets the lower cost of this boom-lift equipment and results in a higher total purchase price for the complete bulk goat unit than for a complete flatbed goat unit.

Apparently a major source of motivation for choosing the modified-bulk system is its interchangeability in handling fruit for either the packinghouse or the processing plant. Although the full-bulk system possesses equal interchangeability in moving fruit from the picker to either the packinghouse or the processing plant, it does not permit as much flexibility at the packinghouse in keeping lots of fruit separate and dealing with any size lot as desired. The use of pallet boxes at the packinghouse in the modified-bulk system permits great flexibility.

The modified-bulk system also offers the same accessibility of fruit for presizing and pregrading as does the full-bulk system.

The box-filling installation is an additional investment that is not included in the pallet-box system. Elaborate box-filling equipment is available, but most packinghouses use lower cost, simple canvas baffles (fig. 21.) However, box-filling and additional box-dumping equipment would be required in a pallet-box system to permit presizing and pregrading.

Since pallet boxes remain at the packinghouse in the modified-bulk system, they should have less wear and tear than in the pallet-box system. However, such data for system costs are not available.

Equipment for the modified-bulk system is listed in tables 13 and 20 (appendix).

Costs

The average costs per field-box equivalent for handling oranges by the modified-bulk system are shown in table 9. Fixed costs for equipment required and direct costs for equipment and labor are included. Fixed and total costs per box decrease as total annual volume increases. The direct costs per box at a given weekly output remain the same for all annual volumes. Table 21 (appendix) gives additional details of these costs.

At an annual volume of 700,000 boxes and 24,000 weekly, total costs per box were $0.1258 less than for a firm with the same capacity and 200,000

TABLE 8.—*Modified-bulk system: Labor requirements for picking-to-packing-line handling of citrus at specified boxes per week*

Worker identity	Workers required for —		
	8,000 boxes per week	16,000 boxes per week	24,000 boxes per week
Grove:			
Picking foreman	1	2	3
Pickers	20	40	60
Bulk goat-truck driver [1]	1	2	3
Road transport, semitrailer-tractor driver [2]	1	2	3
Packinghouse:			
Receiving foreman	1	1	1
Fruit receiver	1	1	2
Pallet-box filler operator	1	1	1
Forklift-truck operators [3]	2	2	3
Pallet-box dumper operator	1	1	1
Total	29	52	77

[1] Number based on 70 field-box equivalents per load, 2,112 feet between picking area and transfer point, and additional 145 feet in picking area for moving between filled baskets.

[2] Number based on 15 miles between transfer point and packinghouse and 325 field-box equivalents per load. Each driver has tractor and complement of 3 semitrailers.

[3] Number based on moving 2 boxes at a time except 4 per trip between empty-box holding area and loading point, 100 feet between empty-box area and loading point, and 80 feet between box-filling station and degreening room, degreening room and dumper, and dumper and empty-box holding area.

TABLE 9.—*Modified-bulk system: Total annual fixed and direct costs for picking-to-packing-line handling of oranges at various weekly and annual volumes*

Weekly volume [1] and costs	Average cost per box for annual volume of—						
	100,000 boxes	200,000 boxes	300,000 boxes	400,000 boxes	500,000 boxes	600,000 boxes	700,000 boxes
8,000 boxes							
Fixed	$0.1391	$0.0695	(2)				
Direct	.4219	.4219	(2)				
Total	.5610	.4914	(2)				
16,000 boxes							
Fixed	.2414	.1207	$0.0804	$0.0603	$0.0482	(2)	
Direct	.3956	.3956	.3956	.3956	.3956	(2)	
Total	.6370	.5163	.4760	.4559	.4438	(2)	
24,000 boxes							
Fixed	.3522	.1761	.1174	.0880	.0704	$0.0587	$0.0503
Direct	.3926	.3926	.3926	.3926	.3926	.3926	.3926
Total	.7448	.5687	.5100	.4806	.4630	.4513	.4429

[1] Field-box equivalents.

[2] Maximum that can be handled annually is less than this volume.

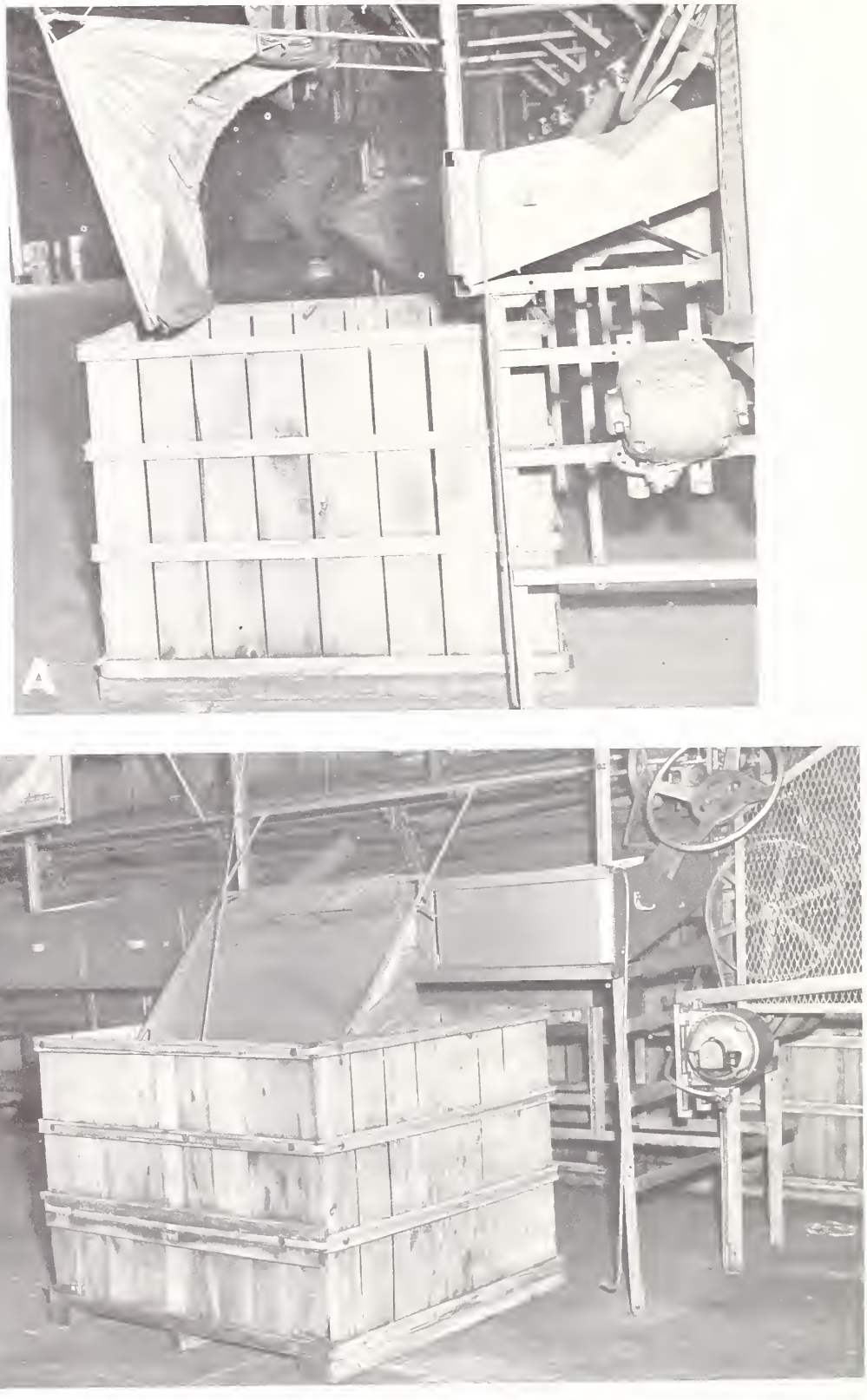


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FIGURE 21.—Equipment for filling pallet boxes with citrus fruit: *A*, In raised position for moving pallet box; *B*, lowered for filling pallet box. The canvas baffles are counter weighted and tend to rise as the fruit piles against them. An operator switching delivery from box to box occasionally assists manually.

boxes annually, but only $0.0485 less than for a 200,000-box volume and 8,000 weekly by a firm equipped to handle 200,000 boxes annually.

At 16,000 boxes weekly and 400,000 annually, costs per box for the modified-bulk system were $0.0850 less than for the field-box system. At a volume of 500,000 boxes annually, the modified-bulk system would save $49,300 per year over the field-box system.

Changes in the total cost per box with increasing annual volume are shown for three weekly rates of output in figure 22.

DISCUSSION AND CONCLUSIONS

Comparative Costs

The systems described for picking-to-packing-line handling of citrus vary in equipment, facilities, techniques, and crew organization or procedures. The equipment required for each system at various weekly volumes is given in tables 14, 16, 18, and 20 (appendix). The annual fixed cost for each piece of equipment is shown in table 13 (appendix). The 1967 list price for new equipment was used for most items to make costs for all systems comparative. A few custom-built machines, such as a bucket elevator constructed on a used truck, deviate from this cost basis. With few exceptions, the full cost of the equipment was charged to the picking-to-packing-line handling of fruit rather than being prorated among several operations.

The cost of ethylene gas for degreening fruit was omitted, as it was common to all systems. However, the cost of degreening rooms and labor equipment used in them was included.

The comparative total costs per box for the four citrus-handling systems are given in table 10. In figure 23 the total-cost curves at various annual volumes are given for firms with a weekly output of 24,000 boxes.

As shown in table 10, a comparatively small firm may achieve a reasonable cost if equipped for only a low weekly volume and if run near capacity. Frequently, however, equipment may be better utilized and cost less per box in a slightly larger

TABLE 10.—*Summary of total annual fixed and direct costs for picking-to-packing line handling of oranges at various weekly and annual volumes for 4 systems*

System and weekly volume (boxes) [1]	Average cost per box for annual volume of—						
	100,000 boxes	200,000 boxes	300,000 boxes	400,000 boxes	500,000 boxes	600,000 boxes	700,000 boxes
Field box:							
8,000	$0.6459	$0.5564	[2]				
16,000	.7987	.6268	$0.5695	$0.5409	$0.5237	[2]	
24,000	.9685	.7142	.6295	.5871	.5617	$0.5447	$0.5326
Full bulk:							
8,000	.5398	.4759	[2]				
16,000	.6442	.5226	.4820	.4618	.4496	[2]	
24,000	.7550	.5761	.5165	.4867	.4688	.4569	.4484
Pallet box:							
8,000	.5466	.4806	[2]				
16,000	.6320	.5135	.4740	.4543	.4424	[2]	
24,000	.7437	.5680	.5094	.4801	.4625	.4508	.4425
Modified bulk:							
8,000	.5610	.4914	[2]				
16,000	.6370	.5163	.4760	.4559	.4438	[2]	
24,000	.7448	.5687	.5100	.4806	.4630	.4513	.4429

[1] Field-box equivalents.

[2] Maximum that can be handled annually is less than this volume.

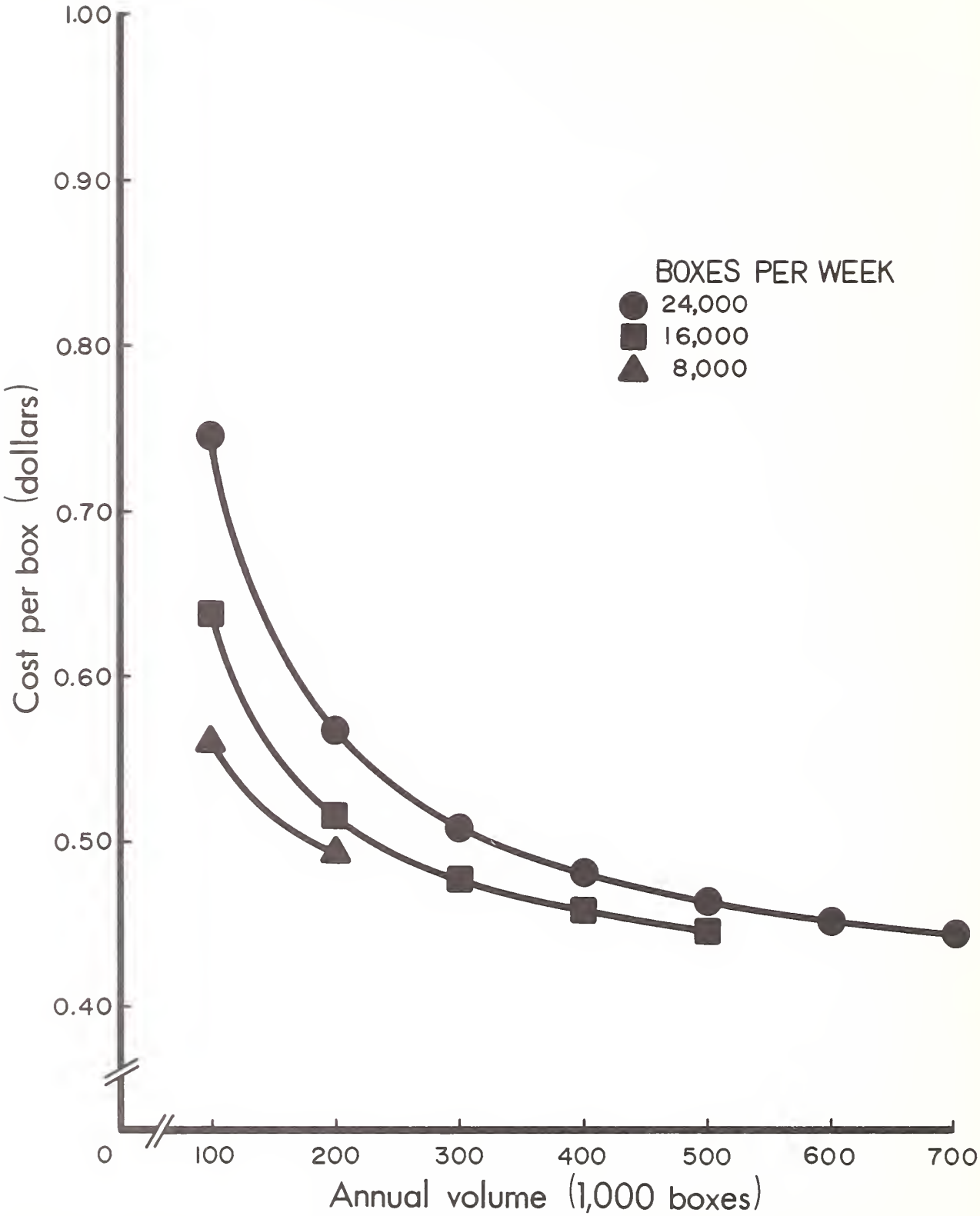

FIGURE 22.—Effect of annual volume on total cost for picking-to-packing-line handling of citrus at three weekly output rates for modified-bulk system.

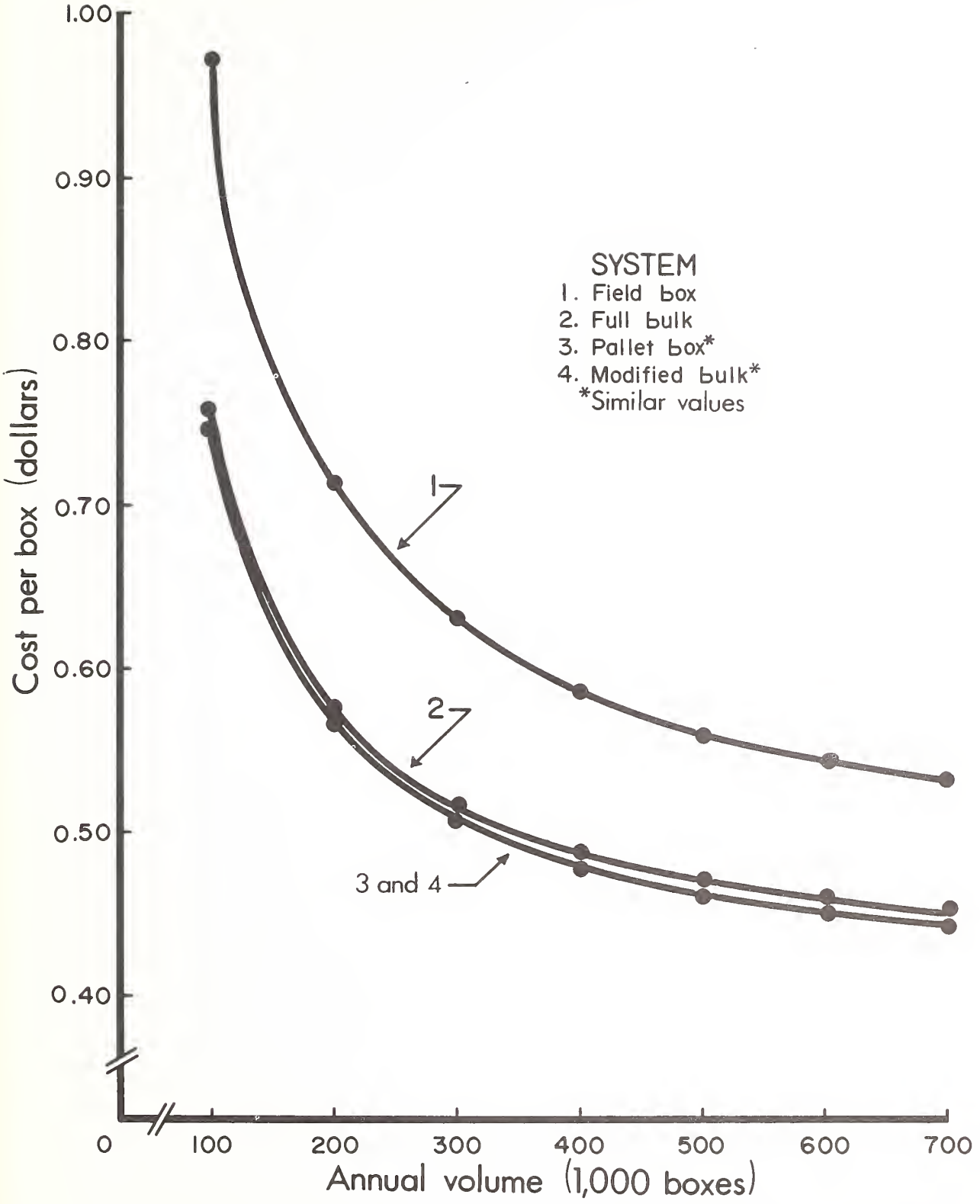

FIGURE 23.—Comparative total costs per box for four citrus-handling systems at various annual volumes and weekly output of 24,000 boxes.

operation. To harvest 16,000 boxes per week may not always require twice as much equipment as for 8,000 boxes. Costs per unit become excessive if an organization equipped to handle a large volume actually handles a small volume.

The field-box system was the most expensive for handling oranges at all volumes, principally because of the cost and the replacement or repair of field boxes. This system also requires more heavy physical labor and suitable workers are becoming scarce. In the other systems machinery takes over the heavy lifting jobs, as in loading.

In the other three systems, the total cost per box was similar. The pallet-box and modified-bulk systems had almost identical costs and had the lowest per-box cost. At 700,000 boxes annually they were essentially the same, $0.4425 and $0.4429, respectively, and the full-bulk system $0.4484. It must be emphasized that these costs are for 1967 wages and prices and do not account for possible further economies within the packinghouse for those systems permitting presizing and pregrading of fruit on arrival at the packinghouse.

Equipment, Facilities, and Other Features

Full-Bulk System

To change existing packinghouse facilities from a field-box to a full-bulk system involves a major construction program to provide the bins for holding and degreening fruit in bulk (*10, 11, 14*).

Conveyors and vertical elevators are necessary to move fruit from the transport vehicle to the filler openings at the top of the bins. Fans, radiators, and other units for air circulation, ventilation, humidification, temperature control, and injection of ethylene gas are needed. Normally all this equipment would have to be acquired because the equipment in old degreening rooms could seldom, if ever, be adapted to the bulk system satisfactorily. Converting to the full-bulk system is expensive. Further details concerning equipment costs are given in table 16 (appendix).

It is simple to arrange for both presizing and pregrading of fruit by installing the necessary equipment in the conveyor system from the unloading station(s) to the bin-filling level. Presizing and pregrading conserve degreening space and thereby reduce both initial equipment cost and operating cost, not only for degreening but also for the packing line because fruit unsuitable for packing has been eliminated. The amount of savings depends on the quantity of fruit coming from the grove and the amount to be packed.

The proportion of fruit eliminated by pregrading will normally be much greater than that by presizing. Grierson and Oberbacher (*7*) indicated that approximately 20 percent of the grove-run fruit could be removed because it is "out of grade" for one of the following conditions: Wind scar, rust mite, melanose, scale, plugged, mechanical injury, and off-shape.

Removal of 20 percent of the total input volume comprised of fruit not good enough to pack will directly increase by 25 percent the productivity of degreening facilities and the packing line up to the discharge end of the sorting table.

As to fruit injury with the full-bulk system, Prosser et al. (*11*) reported that "Damage figures show that fruit handled correctly in bulk is damaged less than comparable fruit handled in field boxes." Fruit is transferred four times in the picking-to-packing-line handling for the full-bulk system (table 23, appendix).

Pallet-Box System

The easiest, although not necessarily the best, way to change from a field-box system to a more modern system will normally be to replace field boxes with pallet boxes and use existing packinghouse facilities with the least modification possible. Focal points on which the appraisal is based are as follows:

(1) Use of existing degreening rooms:

(a) Flooring in rooms and other areas where forklift trucks are used must be sufficiently strong to support the combined weight of the equipment and the usual load of two pallet boxes of fruit. This weight may range from 6,500 to 9,500 pounds—the lower limit reflecting a forklift truck rated at 2,000 pounds at 24-inch load center and the upper limit reflecting a similar truck of 4,000 pounds' capacity.

(b) Doorways into degreening rooms should be large enough for the forklift truck to pass through easily. At least a 2-foot clearance on each side of the truck is desirable. Although qualified operators can handle modern forklift trucks in very close quarters, it is unsatisfactory to have

too much restriction where there are many trips and the passage is routine. Too much restriction slows down the operation, thereby raises costs, and materially increases the probability of an accident.

(c) Air circulation (both fan capacity and air movement) *must* be adequate. Systems adequate for field boxes are often submarginal for pallet boxes and lead to slow, inefficient degreening, low packouts, and increased decay.

(2) Access for forklift equipment to flatbed trucks or semitrailers:

Research and commercial-packinghouse experience have shown that a ground-level paved area on which the forklift equipment unloads filled boxes from, and loads empty boxes onto, road transport equipment is generally more satisfactory than direct dock-to-transport vehicle access.

It may be difficult sometimes to have the ground-level arrangement with existing facilities. Then, proper choice of lift-truck equipment for traveling over dock plates onto flatbed vehicles from the rear is of great importance. Furthermore, safe and sturdy dock plates are essential. A wide variety of dock plates is available ranging from the portable economy-priced, simply-made type to those built into the dock. The latter may even incorporate a mechanism, which is actuated by contact of the vehicle bed to automatically move the plate into position. The decision can be made after considering the cost versus the usefulness of selected types of dock plates.

Direct access from the dock to the rear of flatbed vehicles presupposes that pallet boxes loaded onto the vehicle from the side are "four-way entry" unless they are suitable for clamps as well as forks. In general, handling systems in which lift trucks drive onto semitrailers are not advisable.

An inclined ramp on which forklift trucks may travel between the packinghouse floor and ground level is usually advisable for unloaded trucks only. Normally two forklift trucks would be used—one at ground level moving boxes from the transport vehicle to the edge of the dock and the other at floor level taking the boxes from the dock edge to the degreening room.

If boxes of fruit have to be unloaded and placed temporarily on the ground to promptly release transport vehicles, or if empty boxes have to be placed on the truck or trailer, the ramp provides a way for the forklift truck to be moved outside for this activity.

Fruit-injury findings in pallet-box experiments were summarized by Grierson et al. (*4*) as follows:

> "Biological findings must be regarded as no more than tentative when based on a single season. However, evidence indicates that, with judicious pallet-box handling, damage to fruit certainly need be no more than in presently used field-box handling and may be less. In particular, it should be noted that oranges could be dumped from pallet boxes without significant damage. There is no evidence indicating that fruit damage can be expected to be less than in good bulk handling of oranges. Efficient degreening appears to be no problem at all. The principles used worked so well that it should be possible to design larger pallet-box degreening rooms, using high stacking as is common in deciduous-fruit cold storages."

Such degreening rooms are now in use (*5*).

Fruit is transferred twice in picking-to-packing-line handling in the pallet-box system (table 24, appendix). This is the only system discussed here that does not require more than two transfers, except the field-box system.

For tangerines, charting of the decay percentage values from tests (fig. 28, appendix) did not reveal a consistent pattern of greater injury for fruit handled in pallet boxes than that handled in field boxes.

In the pallet-box system, presizing and pregrading necessitate a greater change in operations than in the full-bulk system. Fruit must be emptied from and returned to pallet boxes before degreening—additional operations not otherwise necessary. Advantages must be weighed against the cost of the additional forklift trucks, box-dumping and box-filling equipment, and personnel required.

Degreening-room design has been changed so that forklift trucks can be used efficiently with pallet boxes. Slatted floors were predominant in

degreening rooms prior to pallet-box usage. As they tended to be unsatisfactory for wheels of forklift trucks with concentrated loads, they were replaced by solid floors.

False ceilings were introduced to provide needed air movement with solid floors. At first the center air stack, which was generally used to distribute air from the fan, was made movable so that travel paths were not obstructed for forklift equipment. Later it was eliminated altogether (*5*).

A diagram of a degreening room is shown in figure 24. The design provides for straight travel paths without turning to reach corners. The rooms formed by canvas curtains provide full width access for forklift trucks. Improved designs for degreening rooms have been published (*5*, *6*).

The degreening-room ceiling normally is much higher for pallet boxes than for field boxes so they can be stacked by lift trucks. In some commercial installations pallet boxes can be stacked six high, although four high is customary in earlier facilities built to handle this container.

Data on degreening-room space utilization were obtained when pallet boxes and field boxes were placed in the same room. Comparisons show that more than twice as much fruit per square foot of floor space can be placed in a room in pallet boxes than in field boxes if pallet boxes are stacked five high (table 11). Degreening with pallet boxes is as satisfactory as with field boxes (*4*).

Design details of pallet-box dumpers may vary considerably. Essential components are a box holder, supporting frame, power source and linkage to operate the box holder, controls, and conveyor parts for moving boxes into and out of the dumping unit. The degree to which the dumper is automatic depends on the need versus the cost for the control components, which probably will be at least $1,100.

The machine must be capable of tipping the box through at least a 120° angle. Some commercial machines turn the box 360°, but only when specifically required, not because it is necessary for emptying the fruit from the box.

Hydraulic systems are used predominantly in these machines to operate the box cradle, with an

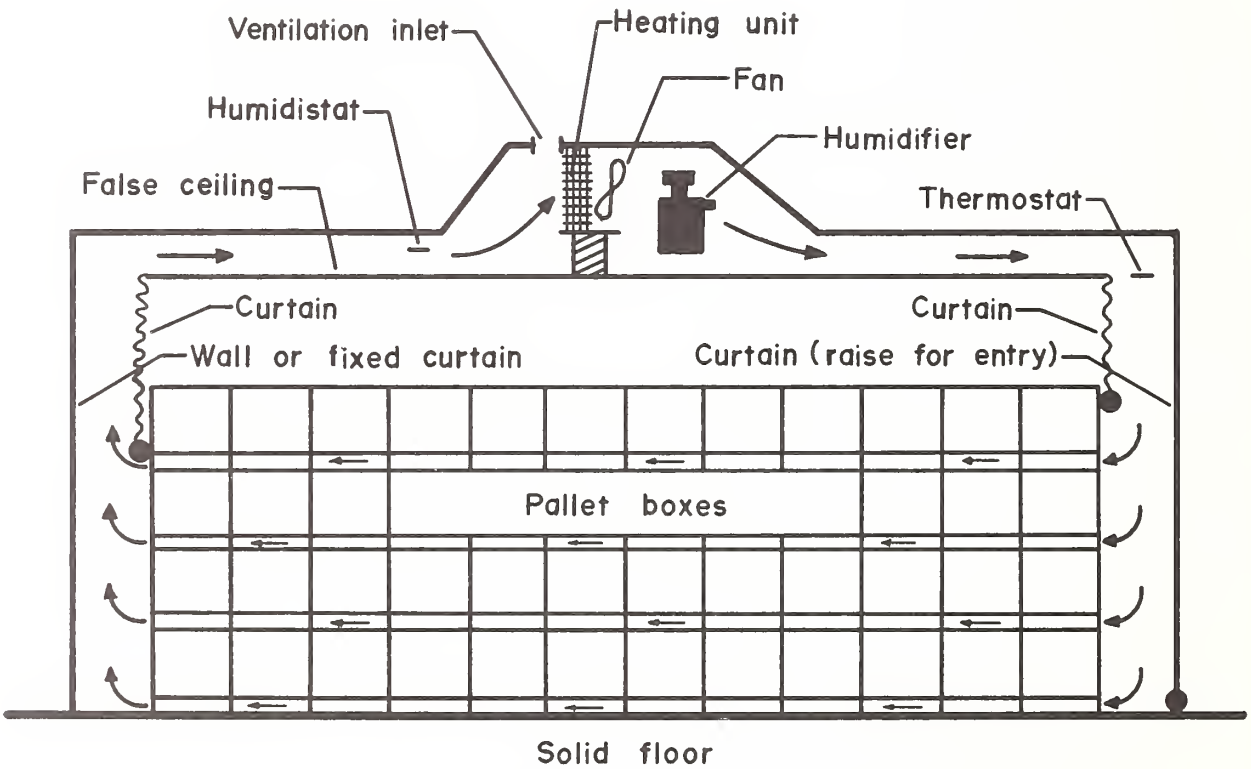

FIGURE 24.—Design of degreening room for fruit in pallet boxes.

TABLE 11.—*Space utilization and fruit capacity for field boxes and pallet boxes in 28- by 30-foot degreening room with ceiling height at least 13 feet*

Item	Field boxes [1]	Pallet boxes [2]
Box placement	10 by 25 rows stacked 4 high.[3]	7 by 7 rows stacked 5 high.
Floor area:		
Theoretical (boxes without spacing)	745 square feet	784 square feet.
Actual [4]	824 square feet	824 square feet.
Utilization ratio, theoretical versus actual.[4]	0.90	0.95.
Fruit capacity per square foot [4]	1.20 field boxes	2.97 field-box equivalents.
Fruit capacity, total for room [4]	988 field boxes	2,445 field-box equivalents.

[1] Outside dimensions: 33 by 13 by 14½ (height) inches.
[2] Outside dimensions: 48 by 48 by 31 (height) inches; capacity of 10 field-box equivalents.
[3] 10 rows on 33-inch dimension; 25 rows on 13-inch dimension.
[4] Excluding space for air stack approximately 16 square feet.

electric motor as the power source. A mechanical linkage can be used and at least one such installation has been noted in Florida.

A hopper and flow-regulating conveyor or other "anti-surge" mechanism are vital to efficient operation of the packing line. The hopper should have a capacity of at least 1½ pallet boxes of fruit so that the dumper can function efficiently. Without a hopper of greater capacity than one box, the dumper must slow down and regulate the flow of fruit. Figure 25 shows how this increases the cycle time of the dumper. In this example the dumping rate is reduced from 117 to 70 pallet boxes per hour.

Other satisfactory "anti-surge" mechanisms include twin parallel belts, of equal capacity but unequal speed, and a slow belt, the full width of the pallet box. The fruit is piled several layers deep on this belt, which moves it onto a faster belt, where the fruit forms a single layer to enter the packing line.

The flow-regulating unit may provide for fruit to be dumped into water and thereby eliminate some possible mechanical injury. In this unit a water tank replaces the dry hopper. An inclined roller conveyor carries fruit from the water to the packing line. A variable speed drive controls the rate of flow to the line. Usually a recirculating pump is needed to impart motion to the water, which will move the fruit to the conveyor. With necessary valves this pump can also serve other needs, such as pumping water out of the tank for cleaning or for repairs to submerged equipment.

Water dumps are not generally advised because of problems in keeping the water sterile and free from trash. Without a controlled fungicide level, the water soon becomes a source of infection for decay.

Automatic machines for unstacking filled pallet boxes for entry to a box dumper and for restacking the empty boxes as they exit from the dumper significantly reduce the workload of forklift trucks and the drivers. The cost of the unstacker and restacker for boxes stacked four high totals approximately $8,000 including automatic controls. The dumper also should have automatic controls when the unstacker and restacker are used with it. Table 12 shows the reduction in time when a forklift truck has an automatic unstacker and restacker.

Such a unit will pay for itself if it reduces the need for forklift trucks by one or more. If no reduction in number of forklift trucks is made possible, the "unstacker-restacker" becomes a convenience rather than an economy.

The length of the entry and exit conveyors for a pallet-box dumper should provide space for enough boxes so as not to force stoppage of the dumper for lack of forklift-truck service in normal circumstances. With the number of forklift trucks planned for the desired dumping rate and given plant layout, the possible variability in time

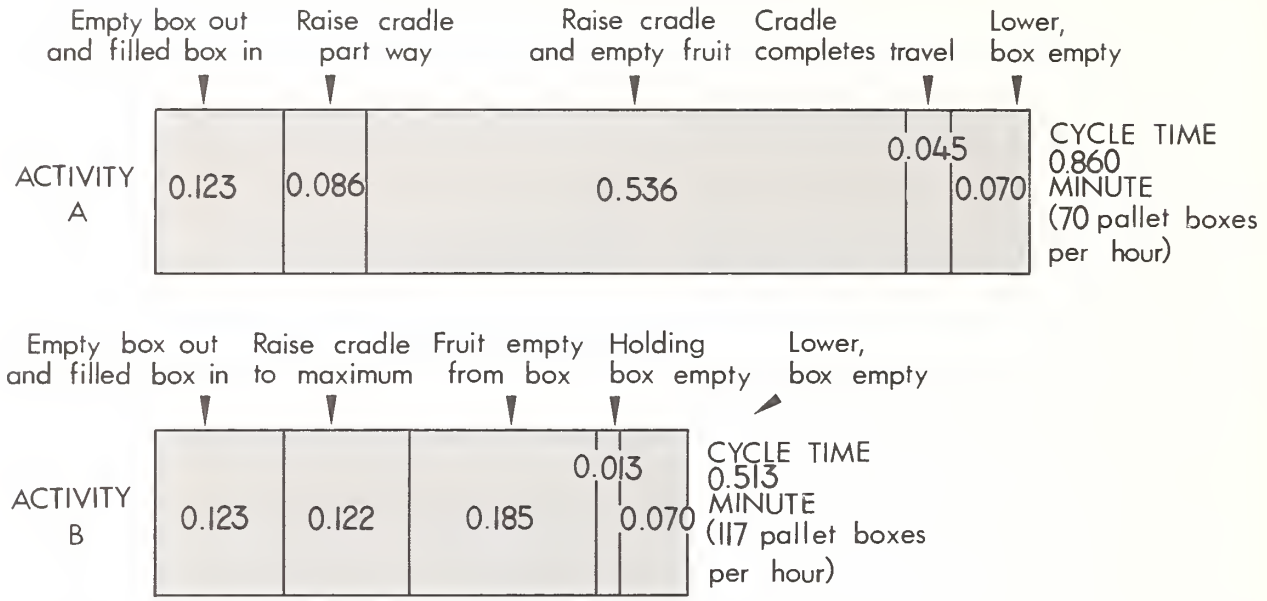

FIGURE 25.—Use of dumper: *A*, To regulate flow of fruit to packing line in element "raise cradle and empty fruit," in addition to dumping; *B*, to dump mainly. Note greater cycle time for (*A*) when dumper cradle cannot be lowered promptly for next cycle.

TABLE 12.—*Reduction in time when forklift truck has automatic unstacker and restacker at box dumper for specified activities*

Activity	Forklift time per cycle						
	Travel	Unstack and stack		Total		Reduction with automatic equipment	
		Without automatic equipment	With automatic equipment	Without automatic equipment	With automatic equipment		
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Percent*
Supply box dumper with boxes of fruit from degreening room (80 ft. one way) and unstack boxes stacked two high at dumper	0. 727	0. 830	0. 393	1. 557	1. 120	0. 437	28
Empty boxes from box dumper to holding area (80 ft. one way) and stack boxes two high at dumper	. 674	1. 095	. 356	1. 769	1. 030	. 739	42

of forklift trips should be considered. It is suggested that space be provided on the conveyors for at least three times the number of boxes to be dumped per minute.

In grove and transport operations the pallet-box system uses part of the equipment usually available in the field-box system, principally goat trucks and flatbed semitrailers. For additional equipment, see tables 14 and 18.

Straddle-trailer handling of pallet boxes between grove and packinghouse is used by one large cooperative in Florida. An outstanding feature of this trailer (fig. 26) is very rapid pickup and release of the entire load. A straddle trailer is nor-

mally never uncoupled from the highway tractor as is done with semitrailers. To utilize this rapid turn-around capability, it is essential to have a very high volume of fruit near enough to the packinghouse so that the straddle trailer can make many round trips daily. Used at full capacity on hauls of optimum distance a straddle trailer can be very economical. Used at partial capacity and over unsuitable distances it loses its economic advantage.

The investment cost is high for a complete straddle-trailer unit, which includes the highway tractor—about $30,000. Scheduling must be accurate for each unit in use to eliminate delay, such as a load not being ready as the straddle trailer arrives at the pickup point. This presents a considerable challenge in view of the variables involved in citrus harvesting and handling.

For semitrailers, scheduling is needed, but accuracy will not be so critical as for straddle trailers. Some variation in loads being ready at transfer points will not necessarily affect all the equipment serving a picking crew.

The coupling or uncoupling of a semitrailer and a highway tractor can be done quickly—possibly 2 to 3 minutes longer than for picking up or releasing a load with a straddle trailer. However, multiple semitrailers are used to move filled and empty boxes between transfer point and packinghouse.

Those making decisions about new equipment will naturally take flatbed semitrailers and the compatible highway tractor equipment as a basis in appraising the desirability of straddle-trailer units. Three semitrailers and one highway tractor currently require an investment no greater, and possibly less, than one complete straddle-trailer unit.

Cost analysis indicated that savings are possible with the straddle trailer, relative to the flatbed semitrailer, when the one-way haul distance is less than 11 miles. At 5 miles the savings would be about 2.8 cents per field-box equivalent. The amount increases as the haul distance decreases.

The decision as to whether straddle trailers will be more desirable than semitrailers involves several factors that may differ somewhat for each firm. Weight given to the same factor may also differ between management groups. The distance of haul and the rate of picking will usually be of greatest importance. As haul distance becomes shorter, any saving in pickup and release time has greater meaning in the overall productivity of the operation. Also a picking rate sufficient to avoid

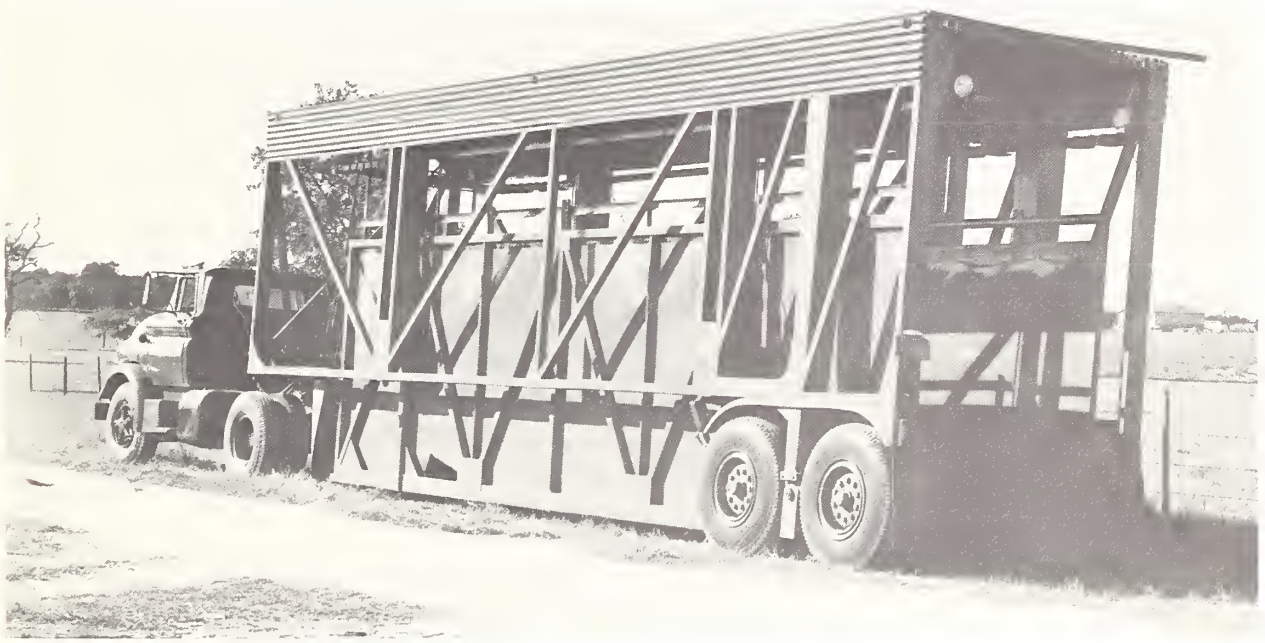

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FIGURE 26.—Straddle trailer at grove transfer point.

waiting for loads with a unit such as a straddle trailer is necessary to realize its capacity.

The quantity of fruit that can be hauled per day for given distances is shown for a straddle trailer and for semitrailers in figure 27.

Modified-Bulk System

The term "hybrid" is descriptive of this system since it is essentially a full-bulk operation from the picker through unloading at the packinghouse and in the packinghouse it is a pallet-box operation.

The modified-bulk system requires that fruit be transferred from one container to another five times—more than in the other three systems. Container here refers to goat trucks and semitrailers as well as baskets and boxes. There is normally a relationship between the number of times fruit is transferred from one container to another and mechanical injury to the fruit. A check of one such system using indicator papers (*3*) and fruit sampling indicated that if equipment is suitably padded, baffled, and not overloaded, any increase in mechanical damage is far less serious than damage commonly caused by delayed handling, low humidity during degreening or holding, or excessive ethylene levels in degreening rooms.

The same grove and transport equipment may be used whether the fruit is designated for fresh use or for processing. This feature is important relative to the total equipment investment required

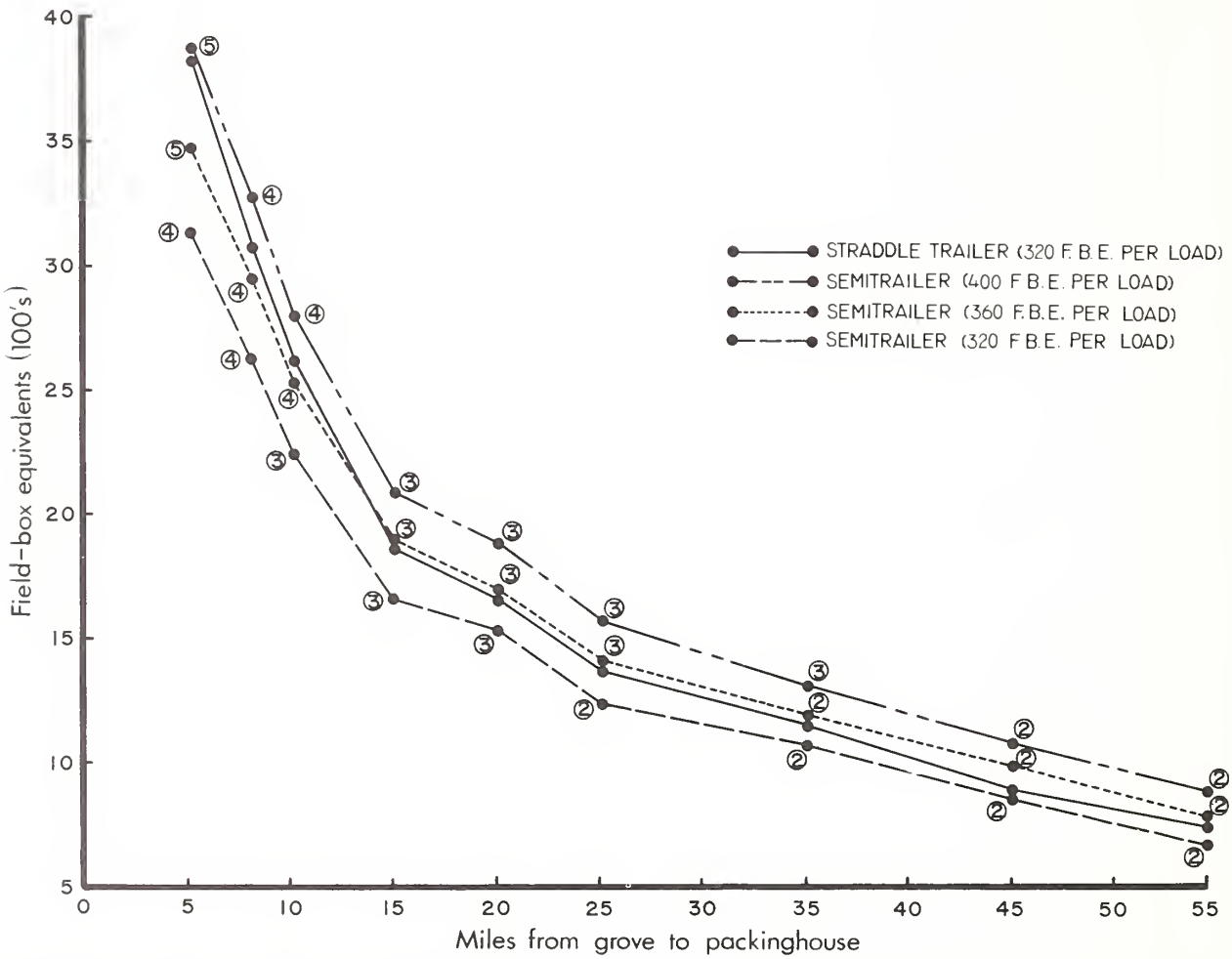

FIGURE 27.—Quantity of fruit hauled per 8-hour day from grove to packinghouse by one straddle trailer and by one highway tractor with flatbed semitrailers (required number indicated in circle).

of a firm. It reduces the amount of investment as compared to handling fresh fruit differently from fruit to be processed. On the other hand, the quality of fresh fruit depends on the management and efficiency of harvesting crews. The temptation to overload trucks (10 boxes per foot of trailer is maximum), let sand get into loader baskets, and fail to sweep out trucks is often irresistible.

At the packinghouse the modified-bulk system provides the same special adaptability for presizing and pregrading as does the full-bulk system. Also, identifying and separating lots of fruit, regardless of the quantity in each, are facilitated by this system as in the pallet-box system. The specialized bin structure, part of the full-bulk system, is not needed.

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APPENDIX

TABLE 13.—*Estimated annual costs of equipment for picking-to-packing-line handling of citrus for 4 systems (based on 1967 costs)*

Equipment	Replacement cost	Salvage value	Service life (years)	Fixed costs				
				Depreciation	Licenses	Insurance and taxes [1]	Interest [2]	Total
Bucket elevator on used truck	$2,500	0	8	$312	$25	$75.00	$70.00	$482.00
Conveyor with motor, 3 by 40 feet, truck to presizer	2,000	0	10	200	0	60.00	55.00	315.00
Conveyor with motor, 3 by 50 feet, truck to presizer	2,500	0	10	250	0	75.00	69.00	394.00
Conveyor with motor, 2 by 100 feet	2,400	0	10	240	0	72.00	66.00	378.00
Crew truck	3,600	$360	8	405	65	108.00	109.00	687.00
Degreening bin—bulk fruit (1,000-box capacity)[3]	10,578	0	20	529	0	317.00	278.00	1,124.00
Degreening room—field boxes (1,000-box capacity)[4]	5,040	0	20	252	0	151.00	132.00	535.00
Degreening room—pallet boxes (1,000-box capacity)[5]	2,400	0	20	120	0	72.00	63.00	255.00
Empty field-box conveyor	4,000	0	10	400	0	120.00	110.00	630.00
Field box (2.23 bu.)	3	0	3	1	0	.09	.10	1.19
Field-box dumper installation	5,000	0	10	500	0	150.00	138.00	788.00
Forklift truck	5,500	550	8	619	0	165.00	167.00	951.00
Goat truck, flatbed	3,500	350	8	394	65	105.00	106.00	670.00
Goat truck with drag chain	3,800	380	8	428	65	114.00	115.00	722.00
Grove carts, 2 wheel (25-box capacity)	250	0	15	17	0	8.00	7.00	32.00
Grove tractor with light hydraulic lift	2,500	250	8	281	0	75.00	76.00	432.00
"Hi-lift" goat truck with boom-type loader	8,200	820	6	1,230	65	246.00	256.00	1,797.00
Pallet box (10-box capacity)	18	0	6	3	0	.54	.52	4.06
Pallet-box dumper installation	5,000	0	10	500	0	150.00	138.00	788.00
Pallet-box filling device (in packinghouse)	3,000	0	10	300	0	90.00	82.00	472.00
Presizer with motor, 200-box-per-hour capacity	2,600	0	10	260	0	78.00	72.00	410.00
Presizer with motor, 400-box-per-hour capacity	3,400	0	10	340	0	102.00	94.00	536.00
Presizer with motor, 600-box-per-hour capacity	4,100	0	10	410	0	123.00	113.00	646.00
Semitrailer, bulk body	5,600	560	12	420	175	168.00	164.00	927.00
Semitrailer, flatbed	5,100	510	12	382	175	153.00	150.00	860.00
Semitrailer, grove cart transport	2,000	200	10	180	25	60.00	60.00	325.00

See footnotes at end of table.

TABLE 13.—*Estimated annual costs of equipment for picking-to-packing-line handling of citrus for 4 systems (based on 1967 costs)*—Continued

Equipment	Replacement cost	Salvage value	Service life (years)	Fixed costs				
				Depreciation	Licenses	Insurance and taxes [1]	Interest [2]	Total
Semitrailer tractor	$7,500	$750	8	$844	$150	$225.00	$227.00	$1,446.00
Tractor forklift	7,200	720	6	1,080	0	216.00	225.00	1,521.00
Trailer to transport wire baskets	465	0	12	39	18	14.00	13.00	84.00
Truck to transport grove tractor forklift [6]	1,250	125	8	141	33	38.00	38.00	250.00
Wire picking basket (10-box capacity)	69	0	8	9	0	2.00	2.00	13.00

[1] Estimated at 3 percent of replacement cost.

[2] Calculated at 5 percent of average values at beginning of first and last year of service life.

[3] Construction cost per 1,000-box capacity = $7,721 (*11, p. 84*).

[4] Construction cost per 28- by 30-foot room or 840 square feet at $6 per square foot (table 11) = $5,040 per 1,000-box capacity.

[5] Construction cost per 28- by 30-foot room or 840 square feet at $7 per square foot (table 11) ÷ 2.450 = $2,400 per 1,000-box capacity.

[6] One-half of fixed cost applied to harvesting operation.

TABLE 14.—*Field-box system: Estimated annual fixed costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Equipment	Fixed cost per unit	Units required and fixed costs at weekly volume of—					
		8,000 boxes		16,000 boxes		24,000 boxes	
		Units	Costs	Units	Costs	Units	Costs
Automatic field-box dumper	$788.00	1	$788	1	$788	1	$788
Camp-lift truck	951.00	1	951	2	1,902	3	2,853
Crew truck	687.00	1	687	2	1,374	3	2,061
Degreening room, 1,000-box capacity	535.00	4	2,140	8	4,280	12	6,420
Empty-box conveyor	630.00	1	630	1	630	1	630
Field boxes	1.19	5,600	6,664	11,200	13,328	16,800	19,992
Goat truck	670.00	3	2,010	6	4,020	9	6,030
Semitrailer, flatbed	860.00	3	2,580	6	5,160	9	7,740
Semitrailer tractor	1,446.00	1	1,446	2	2,892	3	4,338
Total			17,896		34,374		50,852

TABLE 15.—*Field-box system: Direct labor and equipment costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Labor and equipment	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at weekly volume of—		
				8,000 boxes	16,000 boxes	24,000 boxes
Labor:						
Picking foreman	5. 6	$2. 69		$15. 06	$15. 06	$15. 06
Pickers			$0. 285	285. 00	285. 00	285. 00
Loaders			. 054	54. 00	54. 00	54. 00
Semitrailer-tractor driver	5. 0	1. 50		7. 50	7. 50	7. 50
Receiving foreman	[1] 5. 0	1. 50		7. 50	3. 75	2. 50
Receiving helper	[2] 5. 6	1. 15		6. 44	3. 22	2. 15
Clamp-lift truck operators	5. 0	1. 30		6. 50	6. 50	6. 50
Box-dumper operator	[1] 5. 0	1. 30		6. 50	3. 25	2. 17
Empty-box handler	5. 6	1. 15		6. 44	6. 44	6. 44
Payroll taxes, insurance				35. 54	34. 62	34. 32
Total				430. 48	419. 34	415. 64
Equipment:						
Crew truck	5. 0	. 40		2. 00	2. 00	2. 00
Goat truck	15. 0	. 71		10. 65	10. 65	10. 65
Semitrailer, flatbed	15. 0	. 20		3. 00	3. 00	3. 00
Semitrailer tractor	5. 0	1. 85		9. 25	9. 25	9. 25
Clamp-lift truck	5. 0	. 82		4. 10	4. 10	4. 10
Degreening room [3]				1. 58	1. 58	1. 58
Field boxes [4]				3. 28	3. 28	3. 28
Automatic field-box dumper	[1] 5. 0	. 32		1. 60	. 80	. 53
Empty-box conveyor	5. 0	. 19		. 95	. 95	. 95
Total				36. 41	35. 61	35. 34
Total labor and equipment				466. 89	454. 95	450. 98

[1] Estimated at 5 hours per 1,000 boxes for 8,000 boxes weekly, 2.5 hours for 16,000 boxes, and 1.67 hours for 24,000 boxes.

[2] Estimated at 5.6 hours per 1,000 boxes for 8,000 boxes weekly, 2.8 hours for 16,000 boxes, and 1.87 hours for 24,000 boxes.

[3] Maintenance cost per 1,000 boxes estimated at 2 percent of replacement cost.

[4] Maintenance cost per 1,000 boxes estimated at 5 percent of replacement cost.

TABLE 16.—*Full-bulk system: Estimated annual fixed costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Equipment	Fixed cost per unit	Units required and fixed costs at weekly volume of—					
		8,000 boxes		16,000 boxes		24,000 boxes	
		Units	Costs	Units	Costs	Units	Costs
Crew truck	$687	1	$687	2	$1,374	3	$2,061
Light grove tractor with hydraulic lift	432	3	1,296	6	2,592	9	3,888
Grove carts, 2 wheel (25-box capacity)	32	12	384	24	768	36	1,152
Semitrailer, cart transport	325	1	325	1	325	1	325
Goat truck, flatbed	670	1	670	2	1,340	3	2,010
Semitrailer, bulk body	927	3	2,781	6	5,562	9	8,343
Semitrailer tractor	1,446	1	1,446	2	2,892	3	4,338
Bucket elevator, truck mounted	482	1	482	2	964	3	1,446
Unloading conveyor and motor, 3 by 40 feet	315	1	315	0	0	0	0
Unloading conveyor and motor, 3 by 50 feet	394	0	0	1	394	1	394
Presizer, 200 boxes per hour	410	1	410	0	0	0	0
Presizer, 400 boxes per hour	536	0	0	1	536	0	0
Presizer, 600 boxes per hour	646	0	0	0	0	1	646
Bulk degreening bin	1,124	3.2	3,597	6.4	7,194	9.6	10,790
Conveyor, bin to grader, and motor, 2 feet	378	1	378	1	378	1	378
Total			12,771		24,319		35,771

TABLE 17.—*Full-bulk system: Direct labor and equipment costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Labor and equipment	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at weekly volume of—		
				8,000 boxes	16,000 boxes	24,000 boxes
Labor:						
Picking foreman	5.6	$2.69		$15.06	$15.06	$15.06
Pickers			$0.285	285.00	285.00	285.00
Tractor drivers	15.0	1.30		19.50	19.50	19.50
Semitrailer-tractor driver	5.0	1.50		7.50	7.50	7.50
Receiving foreman	[1] 5.0	1.50		7.50	3.75	2.50
Receiving operators	[2] 10.0	1.15		11.50	5.75	3.83
Payroll taxes, insurance				31.15	30.29	30.01
Total				377.21	366.85	363.40

See footnotes at end of table.

TABLE 17.—*Full-bulk system: Direct labor and equipment costs for picking-to-packing-line handling of oranges at 3 weekly volumes*—Continued

Labor and equipment	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at weekly volume of—		
				8,000 boxes	16,000 boxes	24,000 boxes
Equipment:						
Crew truck	5.0	$.40		$2.00	$2.00	$2.00
Goat truck, flatbed	[1] 5.0	.31		1.55	.78	.52
Light grove tractor with hydraulic lift	15.0	.57		8.55	8.55	8.55
Grove carts, 2 wheel (25-box capacity)[3]				.60	.60	.60
Semitrailer tractor	5.0	1.85		9.25	9.25	9.25
Semitrailer, bulk body	15.0	.22		3.30	3.30	3.30
Bucket elevator, truck mounted	5.0	.50		2.50	2.50	2.50
Unloading conveyor and motor	5.0	.12		.60	.60	.60
Presizer	5.0	.13		.65	.65	.65
Bulk degreening bin [4]				5.29	5.29	5.29
Conveyor, bin to grader and motor	5.0	.125		.62	.62	.62
Total				34.91	34.14	33.88
Total labor and equipment				412.12	400.99	397.28

[1] Estimated at 5 hours per 1,000 boxes for 8,000 boxes weekly, 2.5 hours for 16,000 boxes, and 1.67 hours for 24,000 boxes.

[2] Estimated at 10 hours per 1,000 boxes for 8,000 boxes weekly, 5 hours for 16,000 boxes, and 3.33 hours for 24,000 boxes.

[3] Maintenance cost per 1,000 boxes estimated at 5 percent of replacement cost.

[4] Maintenance cost per 1,000 boxes estimated at 4 percent of replacement cost.

TABLE 18.—*Pallet-box system: Estimated annual fixed costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Equipment	Fixed cost per unit	Units required and fixed costs at weekly volume of—					
		8,000 boxes		16,000 boxes		24,000 boxes	
		Units	Costs	Units	Costs	Units	Costs
Crew truck	$687.00	1	$687	2	$1,374	3	$2,061
Tractor forklift	1,521.00	1	1,521	2	3,042	3	4,563
Goat truck with drag chain	722.00	1	722	2	1,444	3	2,166
Truck for tractor forklift	250.00	1	250	2	500	3	750
Pallet boxes	4.06	560	2,274	1,120	4,547	1,680	6,821
Semitrailer, flatbed	860.00	3	2,580	6	5,160	9	7,740
Semitrailer tractor	1,446.00	1	1,446	2	2,892	3	4,338
Forklift truck	951.00	2	1,902	2	1,902	3	2,853
Degreening room (1,000-box capacity)	255.00	4	1,020	8	2,040	12	3,060
Pallet-box dumper	788.00	1	788	1	788	1	788
Total			13,190		23,689		35,140

TABLE 19.—*Pallet-box system: Direct labor and equipment costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Labor and equipment	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at weekly volume of—		
				8,000 boxes	16,000 boxes	24,000 boxes
Labor:						
Picking foreman	5. 6	$2. 69		$15. 06	$15. 06	$15. 06
Pickers			$0. 285	285. 00	285. 00	285. 00
Tractor-forklift operator	5. 0	1. 30		6. 50	6. 50	6. 50
Goat-truck driver	5. 0	1. 15		5. 75	5. 75	5. 75
Semitrailer-tractor driver	5. 0	1. 50		7. 50	7. 50	7. 50
Receiving foreman	[1] 5. 0	1. 50		7. 50	3. 75	2. 50
Forklift-truck operators	[2] 10. 0	1. 30		13. 00	6. 50	6. 50
Pallet-box dumper operator	[1] 5. 0	1. 30		6. 50	3. 25	2. 17
Payroll taxes, insurance				31. 21	30. 00	29. 79
Total				378. 02	363. 31	360. 77
Equipment:						
Crew truck	5. 0	. 40		2. 00	2. 00	2. 00
Goat truck with drag chain	5. 0	. 73		3. 65	3. 65	3. 65
Tractor forklift	5. 0	1. 26		6. 30	6. 30	6. 30
Pallet boxes [3]				1. 97	1. 97	1. 97
Semitrailer, flatbed	15. 0	. 20		3. 00	3. 00	3. 00
Semitrailer tractor	5. 0	1. 85		9. 25	9. 25	9. 25
Forklift truck	[2] 10. 0	. 82		8. 20	4. 10	4. 10
Degreening room [3]				. 75	. 75	. 75
Pallet-box dumper	[1] 5. 0	. 32		1. 60	. 80	. 53
Total				36. 72	31. 82	31. 55
Total labor and equipment				414. 74	395. 13	392. 32

[1] Estimated at 5 hours per 1,000 boxes for 8,000 boxes weekly, 2.5 hours for 16,000 boxes, and 1.67 hours for 24,000 boxes.

[2] Estimated at 10 hours per 1,000 boxes for 8,000 boxes weekly and 5 hours for 16,000 or 24,000 boxes weekly.

[3] Maintenance cost per 1,000 boxes estimated at 5 percent of replacement cost.

TABLE 20.—*Modified-bulk system: Estimated annual fixed costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Equipment	Fixed cost per unit	Units required and fixed costs at weekly volume of—					
		8,000 boxes		16,000 boxes		24,000 boxes	
		Units	Costs	Units	Costs	Units	Costs
Crew truck	$687.00	1	$687	2	$1,374	3	$2,061
"Hi-lift" goat truck with boom-type loader	1,797.00	1	1,797	2	3,594	3	5,391
Trailer for picking-basket transport	84.00	1	84	2	168	3	252
Wire picking baskets (10-box capacity)	13.00	20	260	40	520	60	780
Semitrailer, bulk body	927.00	3	2,781	6	5,562	9	8,343
Semitrailer tractor	1,446.00	1	1,446	2	2,892	3	4,338
Unloading conveyor, 3 by 40 feet	315.00	1	315	0	0	0	0
Unloading conveyor, 3 by 50 feet	394.00	0	0	1	394	1	394
Presizer, 200 boxes per hour	410.00	1	410	0	0	0	0
Presizer, 400 boxes per hour	536.00	0	0	1	536	0	0
Presizer, 600 boxes per hour	646.00	0	0	0	0	1	646
Pallet-box filling device	472.00	1	472	1	472	1	472
Pallet-boxes (10-box capacity)	4.06	480	1,949	960	3,898	1,440	5,846
Forklift truck	951.00	2	1,902	2	1,902	3	2,853
Degreening room (1,000-box capacity)	255.00	4	1,020	8	2,040	12	3,060
Pallet-box dumper	788.00	1	788	1	788	1	788
Total			13,911		24,140		35,224

TABLE 21.—*Modified-bulk system: Direct labor and equipment costs for picking-to-packing-line handling of oranges at 3 weekly volumes*

Labor and equipment	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at weekly volume of—		
				8,000 boxes	16,000 boxes	24,000 boxes
Labor:						
Picking foreman	5. 6	$2. 69		$15. 06	$15. 06	$15. 06
Pickers			$0. 285	285. 00	285. 00	285. 00
Bulk goat-truck driver	5. 0	1. 30		6. 50	6. 50	6. 50
Semitrailer-tractor driver	5. 0	1. 50		7. 50	7. 50	7. 50
Receiving foreman	[1] 5. 0	1. 50		7. 50	3. 75	2. 50
Fruit receiver	[2] 5. 0	1. 15		5. 75	2. 88	3. 83
Pallet-box filler operator	[1] 5. 0	1. 30		6. 50	3. 25	2. 17
Forklift-truck operators	[3] 10. 0	1. 30		13. 00	6. 50	6. 50
Pallet-box dumper operator	[1] 5. 0	1. 30		6. 50	3. 25	2. 17
Payroll taxes, insurance				31. 80	30. 03	29. 81
Total				385. 11	363. 72	361. 04
Equipment:						
Crew truck	5. 0	. 40		2. 00	2. 00	2. 00
Pallet boxes [4]				1. 69	1. 69	1. 69
Wire picking baskets [4]				. 27	. 27	. 27
"Hi-lift" goat truck with boom-type loader	5. 0	1. 55		7. 75	7. 75	7. 75
Semitrailer, bulk body	15. 0	. 22		3. 30	3. 30	3. 30
Semitrailer tractor	5. 0	1. 85		9. 25	9. 25	9. 25
Trailer for picking-basket transport [4]				. 09	. 09	. 09
Unloading conveyor	5. 0	. 12		. 60	. 60	. 60
Presizer	5. 0	. 13		. 65	. 65	. 65
Pallet-box filling device [4]				. 59	. 59	. 59
Forklift truck	[3] 10. 0	. 82		8. 20	4. 10	4. 10
Pallet-box dumper	[1] 5. 0	. 32		1. 60	. 80	. 53
Degreening room [5]				. 75	. 75	. 75
Total				36. 74	31. 84	31. 57
Total labor and equipment				421. 85	395. 56	392. 61

[1] Estimated at 5 hours per 1,000 boxes for 8,000 boxes weekly, 2.5 hours for 16,000 boxes, and 1.67 hours for 24,000 boxes.

[2] Estimated at 5 hours per 1,000 boxes for 8,000 boxes weekly, 2.5 hours for 16,000 boxes, and 3.33 hours for 24,000 boxes.

[3] Estimated at 10 hours per 1,000 boxes for 8,000 boxes weekly and 5 hours for 16,000 or 24,000 boxes weekly.

[4] Maintenance cost per 1,000 boxes estimated at 5 percent of replacement cost.

[5] Maintenance cost per 1,000 boxes estimated at 2 percent of replacement cost.

TABLE 22.—*Summary of activities for field-box system*

Activity [1]	Total occurrences	Distribution of total occurrences by specified number of field-box equivalents per occurrence				
		1	2	4	60	360
Operations (○)	[2] 15	8	1	5		
Transportation (⇨) by—	12	3	2	3	2	2
Man	3	1	2			
Hand-clamp truck	2			2		
Semitrailer tractor	2					2
Goat truck	[3] 2				2	
Dumper drag chain	1			1		
Conveyor to line	1	1				
Conveyor, empty box	1	1				
Delays (D)	4	1				3
Storages (▽)	[4] 2					1
Inspections (□)	0					

[1] Fruit transferred twice in picking-to-packing-line handling—picking bag to box and box to packing line.

[2] Degreening included in total only; rooms vary widely in capacity.

[3] Distributing empty boxes from moving goat truck included in operations.

[4] Storage in empty-box shed included in total only; capacity may vary considerably for different sheds.

TABLE 23.—*Summary of activities for full-bulk system*

Activity [1]	Total occurrences	Distribution of total occurrences by specified number of field-box equivalents per occurrence		
		1	25	325
Operations (○)	[2] 11	2	4	2
Transportation (⇨) by—	12	2	3	7
Man	1	1		
Cart tractor	2		2	
Vertical elevator	2		1	1
Semitrailer tractor	2			2
Conveyor to bins	4			4
Conveyor to line	1	1		
Delays (D)	3		1	2
Storages (▽)	0			
Inspections (□)	[3] 1			

[1] Fruit transferred 4 times in picking-to-packing-line handling—bag to cart, cart to semitrailer by vertical elevator, semitrailer to bin by conveyor and vertical elevator, bin to packing line.

[2] Includes presizing, degreening, and bin unloading in total only.

[3] Pregrading; does not regularly occur by specified number of field-box equivalents.

TABLE 24.—*Summary of activities for pallet-box system*

Activity [1]	Total occurrences	Distribution of total occurrences by specified number of field-box equivalents per occurrence				
		1	10	20	40	360
Operations (○)	[2] 16	2	2	11		
Transportation (⇩) by—	12	2	2	4	2	2
Man	1	1				
Tractor forklift	[3] 2				2	
Forklift truck	4			4		
Semitrailer	2					2
Dumper conveyor	2		2			
Conveyor to line	1	1				
Delays (D)	4		1			3
Storages (▽)	[4] 2					1
Inspections (□)	0					

[1] Fruit transferred twice in picking-to-packing-line handling—picking bag to box and box to packing line. Presizing and presorting fruit would require 2 additional transfers.

[2] Degreening included in total only.

[3] Placing boxes for pickers included in operations.

[4] Of two occurrences, one depends on capacity of empty-box storage and other is per semitrailer load of empty boxes near grove.

TABLE 25.—*Summary of activities for modified-bulk system*

Activity [1]	Total occurrences	Distribution of total occurrences by specified number of field-box equivalents per occurrence					
		1	10	20	30	70	325
Operations (○)	[2] 21	2	3	8	2	2	2
Transportation (⇩) by—	18	1	4	3	1	4	5
Man	1	1					
Bulk goat truck	5		1			4	
Semitrailer	2						2
Empty-basket trailer	1				1		
Conveyor to box filler	3						3
Forklift truck	3			3			
Dumper conveyor	2		2				
Conveyor to line	1		1				
Delays (D)	3		1				2
Storages (▽)	4		2		1	1	
Inspections (□)	[3] 1						

[1] Fruit transferred 5 times in picking-to-packing-line handling—bag to basket, basket to bulk goat truck, goat truck to semitrailer, semitrailer to pallet box, pallet box to packing line.

[2] Degreening and presizing included in total only.

[3] Pregrading; does not regularly occur by specified number of field-box equivalents.

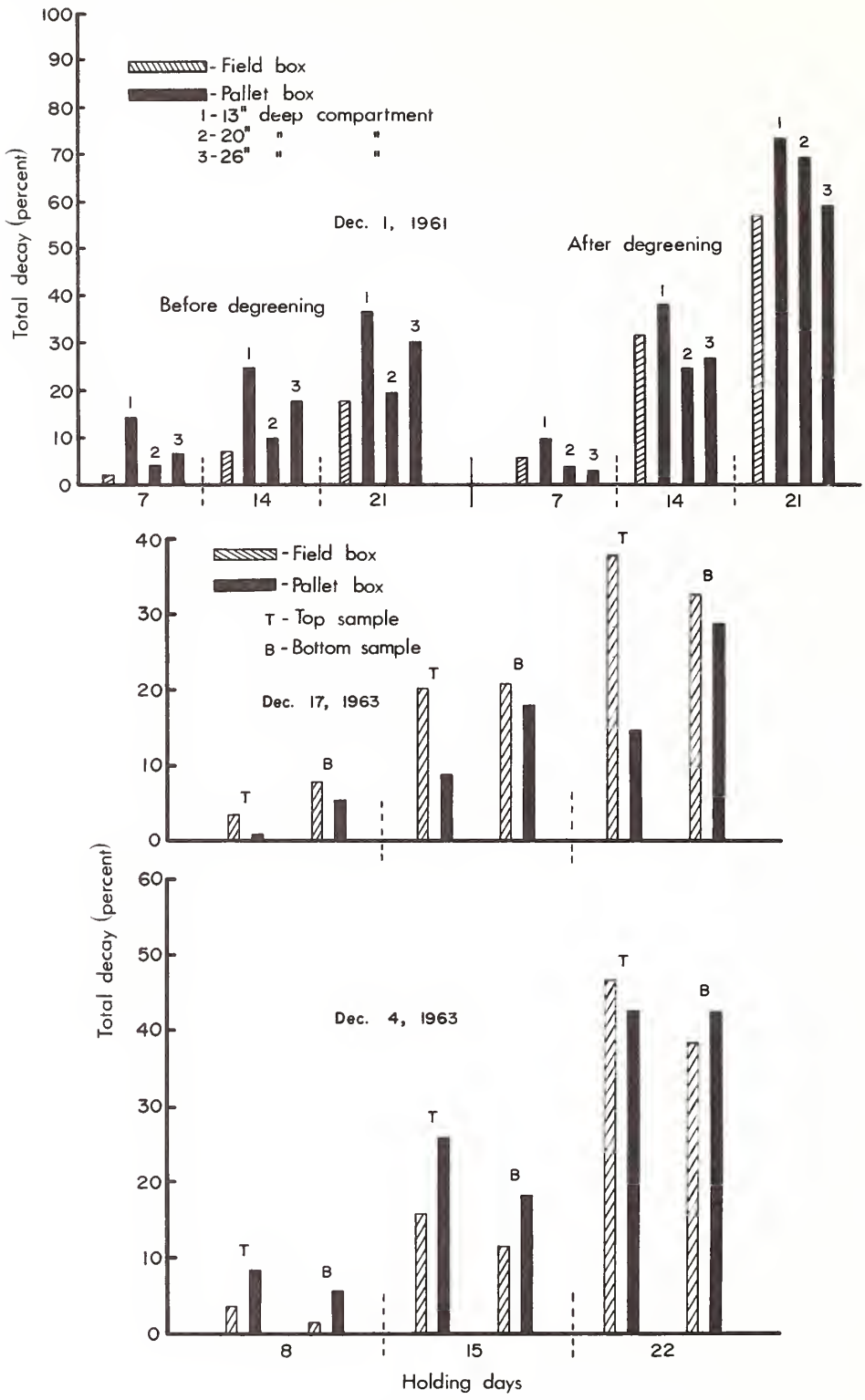

FIGURE 28.—Decay resulting from injury when tangerines in both field boxes and pallet boxes were hauled from grove to packinghouse on same truck in several tests, 1961–63.

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